Man on his Nature

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Man on his Nature

by

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Preface

I FIND a word of preface is expected for this volume, and it comes welcomely to me here to thank the University of Edinburgh for the invitation to give these lectures. The invitation indeed overcame some hesitation on my part which readers of these pages, I can think, may find intelligible.

As to acknowledgements, Sir S. R. Christophers, F.R.S., a friend of many years, has been so kind as to read through for me in proof an excursion into the parasitology of malaria made in my final chapter. To my friend Mr J. Reid Moir, F.R.S., I am indebted for a like good office in regard to the text's occasional references to ways and works of prehistoric man, and other kindred themes.

At numerous places, especially in its opening chapters, my text turns to the writings of a sixteenth-century physician, Jean Fernel, a figure probably now little known except to the historian of Medicine. It is hoped, however, to issue about him in the near future a more documented account, biographical and bibliographical.

Lastly I would acknowledge with gratitude the care and skill given to the issue of this volume by the University Press, and I would convey my thanks to Dr Robert Chambers for his readiness to allow me the reproduction of two noteworthy microphotographs from his laboratory.

C. S. S.

August 1940

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NATURE AND TRADITION

Quemcunque aegrum ingenio praestantem curandum invisebat, siquidem morbi vehementia pateretur,. . .familiarem cum eo sermonem aliquandiu conferebat, cum philosophis Philosophica, cum Mathematicis Mathematica, cum ducibus ac militibus, de urbium situ, et fluviis eas alluentibus, deque instrumentis bellicis et eorum inventoribus; cum nautis de navigandi ratione et regionibus nuper repertis; cum Theologis de Deo.

Life of Jean Fernel, by GUILLAUME PLANCY, published (1607) in the Univ. Medicina.

When consulted by some patient who was a man of parts he (Fernel), if the state of the case allowed, liked to get some talk with him; if it were a philosopher on philosophy, if a mathematician on mathematics, if a commander or a soldier on the site of towns, the rivers on which they were, and on engines of war and their inventors, if a seaman on navigation and newly discovered lands, if a theologian on God.

I

As to Natural Theology and what we are to understand by it, more than one well-known statement offers us counsel. Bolingbroke, type in his way of eighteenth-century culture, wrote to Alexander Pope, the poet, "What I understand by the first philosophy is 'natural theology', and I consider the constant contemplation of Nature, by which I mean the whole system of God's works as far as it lies open to us, as the common spring of all the sciences, and of that", i.e. Natural Theology. The words in which the founder of these Lectures expressed his intention allow us to think Bolingbroke's statement might have satisfied him well. There is, too, Lord Bacon's famous definition:* that "spark of knowledge of God which may be had by the light of nature and the consideration of created things; and thus can be fairly held to be divine in respect of its object and natural in respect of its source of information". Professor C. C. J. Webb quotes the founder of the Wilde Lectureship to the effect that "Natural Science is regarded as the basis of Natural Religion and therefore of Natural Theology".†

As to this last, Natural Science in its progress can provide a frame of reference for Natural Theology, but within that frame the latter's argument has to be her own. Natural Science changes. It changes sufficiently for its change to carry change into what is based upon it. Changes of detail, however, need not involve change in principle. But what Natural Theology looks to in Science are Science's generalizations about Nature.

Natural Science is a branch of knowledge by general consent not primarily based on the *a priori*. It derives essentially from details. It amasses them and lives on and by them. Its generalizations so built up are even when arrived at constantly being controlled by fresh details. In that way its generalizations do from time to time suffer change. Natural Theology is interested in this as a background and context for its own text.

The standpoint of Natural Theology looking at Nature is not

* *De Augmentis*, iii, 2.

† *Studies in the History of Natural Theology*, p. 2, 1915.

like that taken by Natural Science. If we enquire where the general difference between them lies an answer might be that the latter observes and endeavours by observation to follow and trace the 'how' of what happens in Nature. It proceeds further to generalize about this 'how'. It tries to decipher something of it in the past and to forecast something of it in the future. Above all it expends its utmost pains on attempting to describe the 'how' fully and accurately by first-hand observation at this present. Natural Science would probably admit that what impels it thus to labour and strive is not purely a disinterested desire for knowledge for its own sake. Mankind has found that to understand the 'how' of natural events brings with it increased power to exploit Nature; and that power brings with it in its turn advantages and amenities for human life. In short, this urge driving man toward natural knowledge is just part of the human aspect of the 'zest to live' which biological study finds actuating the behaviour of all living things. Not that Natural Science would admit, nor is it implied in the above, that Science's sole curiosity about Nature regards the material benefits it can extract thence. It would hasten to add, and with all sincerity, that at least in part its object is to learn the 'how' of Nature for the sake of that 'how' itself as being one aspect of 'truth'.

What however it does not include within its scope and does not set itself to ask is whether that 'how' is 'good' or 'bad', or whence that 'how' may ultimately derive. On the other hand, Natural Theology when it enquires into Nature does enter into both these questions. This scope implies a different attitude toward Nature on the part of the two enquiries. The position can no longer be compared with that of a child watching a performance and trying to see how it is done. Rather it is something like that of a juror summoned to a trial there to enter into deeds and motives and apportion praise or blame. It is a position which times out of number has been assumed with all reverence, and its responsibilities, thus judged incumbent, faithfully discharged in that spirit. But inherent in it is a certain implication which lends itself in this case to misconception. It could be urged that for an infinitesimal fraction of a vast and unthinkably complex whole, which the said fraction cannot fully even perceive let alone comprehend, to set itself to pronounce on the excellence of that whole or to judge whether the motives of the whole are good or bad, or its events ill or praiseworthy, is for that minute fraction of the whole to commit a trespass against its own intelligence and to show a misconception of its own ethical proportions. Coming from such a quarter praise or blame, it might be urged, is equally an impertinence. To enter upon such a position is for human reason to allow itself an inconsequence. But though the worth of a judgment reached under such circumstances may in the abstract amount to nothing, and in its application to the whole be completely negligible in value, the possibility may yet well be that it is worth while to man for the reaction upon man himself. It may well be that to assume such a position, though that position, regarded purely logically and as a standpoint for review of the whole, seem almost fantastically 'anthropist', and miscalculated, is a step called for from man in duty to himself. If he have a duty towards himself or to his kind and his surrounding, then this purview he would adventure, as to the meaning of this whole of which he finds himself a part, may well be of true profit to himself and his own kind. That he should attempt it appears one other aspect of his striving after Truth, even as his adventure into Natural Science is one aspect of that same endeavour. There would seem therefore to be between Natural Theology and Natural Science in some degree an aspiration in common, and in some measure a potential common ground on which both stand.

For them both, as regards the scope of what is understood by the word Nature, acceptance of man as belonging within the province of Nature is of importance here. The Natural Theologist, if we may so address him, in his effort from consideration of Nature without appeal to revelation to come to a conclusion about the existence and ways of God has thus to include himself as part of the natural evidence. He then sees himself as a piece of Nature looking round at Nature's rest. Man taken as a phenomenon of Nature, Nature then carries with it besides all its rest an object of transcendent import for man's interpretation of Nature. I would think that a man for whom the human is not a part of Nature can scarcely enter fully into Natural Religion. Nature in his case becomes a background for a human actor who is not of it, a being who treats it as a background merely. Under that relation Natural Religion has not its full meaning. The province of Natural Theology is surely to weigh from all the evidence derivable from Nature whether Nature taken all in all signifies and implies the existence of what with reverence is called God; and, if so, again with all reverence, what sort of God. The human abstracted from it, Nature as to its rest would be from this point of view a category presenting no concrete mind which seems to experience 'values'. Nature becomes however a different object of contemplation for man if it faces him with a situation in which, so far as he can grasp it, Nature, in virtue of himself, has now entered on a stage when one at least of its growing points has started thinking in 'values'. This comes before him as part of the evidence to be considered.

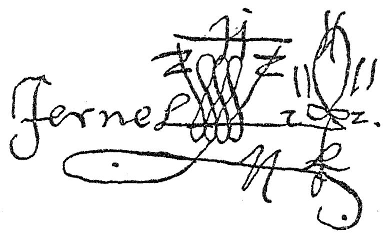
The onward stream of scientific thought, although unhalting, yet so twists and eddies that the direction of its general trend may not at a given moment be plain to read. The trend can be better judged by comparison of general positions taken with significant interval apart. Thus, a period altogether earlier than our own set over against our own. The farther apart the greater the contrast, for Science on the whole is steadily cumulative of change. There are however limits to the advantage of the greater distance. The science of a more remote age is usually more difficult to recapture. It may so interlock with collaterals of its time little like those of our own that the comparison becomes a problem of several variables instead of one. For us to read what was inferred from the Natural as to the Divine under the faith of a former age, that former faith must not have viewpoints too unlike ours of today. To read the inferences may then be impossible. Scientific outlook is always part of its age. If we seek it back far prior to ourselves it may be so entangled with society and sentiments other than ours it cannot well be assessed in its own right.

We have to look for a time and scene sufficiently akin to our own for us to share the viewpoints, and then to lay the science along with its religious implications conformably beside our own. The mid-Renaissance seems a time which offers such opportunity. The Renaissance often dates as the beginning of the modern age. Searched for a concrete text which shall sample it not unrepresentatively, it has indeed several. Among them is one which I am taking as suitable to our purpose—a quasi-philosophical treatise, much read in its day and indeed for long after, the work of a physician, perhaps the foremost of his age. Its author, living in Paris in contact with the Court and consulted by patients and their physicians from far beyond the borders of France itself, was of liberal view and a reformer in Medicine and its teaching. The work, though never issued in the vernacular, was addressed to the general reader of that time. It is a disquisition on man's place in Nature. The writer before turning actively to medicine had been a lecturer on Philosophy in his College within the University of Paris. He was distinguished also in mathematics, and had turned with enthusiasm to Astronomy and Geodesy. It is his book, "On Hidden Causes" (*De Abditis Rerum Causis*), which can serve us for a text. When it was written he was already entering on a great career in medicine.

At that time, the mid-sixteenth century, medicine was still largely within the charitable charge of the Church. Jean Fernel however, unlike our own Linacre, his senior contemporary, was not in holy orders. As a physician he was remarkable in more than one respect. Of transcendent reputation for success at the bedside both with the Court and wealthy and with the poor who flocked to him, he was, too, the earliest to draw together into one discipline physiology, calling it for the first time by that name, and holding it to be the necessary introduction to scientific medicine. From his Paris folio of 1542, finely printed by Simon de Colines, the modern text-book of physiology starts. In the schools his preoccupation had been rather with cosmology and Cicero, and Aristotle and Pliny, than with patristic learning. What the physician thought about Nature has in every age reflected much of the instructed opinion of the time. His calling, too, has always led him to view Nature with man as its central interest. It is so here. The background of the book and of its author is on the one hand the humanistic revival still in flood, and on the other hand religious strife, not least in

France, beginning in its bitterness to use fire and sword. Of this latter our book in its self-contained earnestness bears little or no mark.

Jean Fernel was physician to Henri II of France, and to that King this book is dedicated. Circulated in MS. for some years, it was printed in 1548 and then reprinted many times. It



found readers still for another 100 years.* It must have said something which part at least of the mind of Christendom was thinking at that time. Reprintings in Italy, Switzerland, Germany and the Low Countries as well as France during a 100 years testify to a considerable and faithful public; and never in the vernacular, is some evidence of an audience which had more than attended school. Its dedication says something of how the book

* More than thirty issues within the 100 years.

came to be written. An aphorism in Hippocrates had long teased Fernel's thought—that sentence which asks "whether in disease there is not something supernatural"—τὸ θεῖον, *quid divinum*?

That Fernel's mind should be turning this question over is significant both of the man and of the time. The sentence had been dealt with as far back as Galen. Galen had not read into it a suggestion of the supernatural. One of the most famous of the Hippocratic writings, that "On the Sacred Disease", explicitly rejects the attribution of disease to the supernatural. But to Fernel's ear, in an age more sophisticated than that of the old healers of Cos, the very brevity of the question "Is there the supernatural in disease?" savoured of something suppressed and something more to tell. For Fernel we must remember the question spoke across centuries beset with magic and miracle. Might not Hippocrates, the ancient oracle of medicine, choose to convey a profound truth in cryptic form, with intent that, for a time, only the wise might decipher it?

So Fernel enters on his "Dialogue".* Two of its characters are seeking the third, a physician, to put to him this same question from Hippocrates. They put it from themselves as a living question of the time, the mid-sixteenth century. In considering it, Fernel begins at the beginning. That was his way. His early excursion into Geodesy took him forthwith to remeasuring the earth and his measurement long remained memorable. So here this question about sickness leads him at once to asking what is man, and what the structure of the world. He does not separate this study of man from that of Nature.

His acceptance of man as within Nature is of significance to us here. It means that his Natural Theology agrees to include man himself as part of natural evidence. Man and his mind loom up as part of the evidence to be considered. To Hume they did so too but in a different form.

Fernel, in his desire to begin at the beginning, is not afraid of asking questions, even when in his sincerity he cannot furnish an answer. What is Nature? he asks. Neither the Hippocratic writers nor Aristotle he thinks, much as they speak of Nature, have sufficiently defined it. Perhaps Aristotle's resolution of it

* Page-references to Fernel are to the page-numbers of the Utrecht edition, 1656.

into movement was too radical for him. Aristotle's "Universal* Nature" he thinks can be taken as the equivalent of Plato's *Anima Mundi*, and he† approves Tully's remark that such a 'Nature' must mean a supreme Deity. Fernel submits Nature is a Principle evident but not itself isolably demonstrable. "Have you ever seen it and taken it up in your hands?" asks Brutus. Philiatros answers, "I do not try to look by actual vision at what I follow in a train of thought."

Fernel has cast his treatise as a Dialogue, a form favoured by philosophers. Plato declared thinking itself to be dialogue within the soul. Professor Spearman perhaps might not endorse that. Fernel's Dialogue has three characters. Brutus is, as we might say, the man in the street, a cultured man in the street in sixteenth-century Paris, in the University quarter. Brutus I fancy as a man who, today, from his club would indite letters to the daily paper, to the best daily paper. He airs his views and likes to encounter others. He cites Plato and has on his tongue‡ couplets from Augurello's poem§ on alchemy and the transmutation of metals to gold. Philiatros is the other and a younger character. The name at that time in Paris denoted a senior candidate for the Doctor's degree. Philiatros is primed with learning of the Faculty. At one point in an argument in the Dialogue he suggests that while Eudoxus takes the Aristotelian side and Brutus the Platonic, he himself will adduce Holy Writ. Eudoxus, in the Dialogue, is a physician senior to his two friends; he stands for Fernel himself.

Nature is not what we heard Bolingbroke call "the whole system of God's works as far as . . . open to us"; nor is it Bacon's "created things". It is a principle, seized by the mind *a priori*, but confirmed inductively. A 'cause'. The cause of the manifold of the perceptible world around us. Not in antithesis to man, but rather in corollary to man. The works of Nature stand in relation to Nature as do products of the arts and crafts to man. As when seeing a statue we know there must have been a sculptor, so when we see a mountain, a tree, or a bird, we know there must be an immediate cause for it, and that immediate

* *Dialog.* ii, 18. † *Dialog.* ii, 7.

‡ *Dialog.* ii, 18.

§ *Chrysopeia*, Venice, 1515, printed by Simon de Luere.

cause is Nature. Fernel declares that Aristotle himself felt that the existence of such a Nature must mean a Supreme Deity.*

But, and that is capital with Fernel, man himself, apart from his immortal soul, is of the works of Nature. Of Nature as an immediate cause. For man to be insisted on as a work of Nature points we may think to the physician in Fernel. A century later than Fernel the charge became common that the physician was essentially irreligious. The saying went that he knelt not to God but to Nature. The reply of Fernel would perhaps have been that the physician resorts to God through Nature.

Nature in any case was of intense interest to Fernel throughout. For most men at that time other interests surrounding life had more powerful appeal than Nature. But for Fernel, amid all his great practice both at Court and outside it, in contact with careers and men of all conditions, alert and knowledgeable,† Nature remained his transcendent interest, and man, individual man, was for him the crown of Nature. To hold man as Nature's work he found in no respect out of harmony with his Christian faith. He went unquestioned and unscathed through all that time of bitter religious conflict. Ignatius Loyola, a few years the older, was his junior fellow-student at the same College. He drew from Nature evidence of a sovereign power and intellect, which he identified with God. His natural religion made for Fernel only a part, though a large part, of his religious situation. He was unlike the type of physician frequent later on in the seventeenth and eighteenth centuries, for whom Nature was, if he had any religion, his whole religion. Nature was not for Fernel and his time, nor for a hundred years to come would be, a self-sufficing Reign of Law; Galileo and Newton had not yet touched the 'unmoved Prime mover' of the spheres. Nature did not utterly dominate Fernel's religion. Still less was Natural Religion his whole religion. He had too his religion based on the Christian verities. And these two were for him not two religions, but one religion. With Fernel to have a system was a necessity. For him his Natural Religion and his religion of faith must harmonize. They must not be inconsistent. Otherwise life had no peace, no plan, nor direction to follow.

* *Dialog.* ii, 7. † Plancy's *Vita*, p. **2.

In a passage, written some four years before his death when he was at the height of his professional fame, and was as a philosopher-physician by name as familiar at the Emperor's Court as at the King's, he wrote* what amounts to a sort of succinct 'credo' about Nature thus:

"Nature, embracing all things and entering into each, governs the courses and the revolutions of the sun and moon and of the other stars, and the succession of times, the change of the seasons, and ocean's ebb and flow. Nature rules this immensity of things with an order assured and unvarying. How were it possible for Nature so to conduct and direct all this thus well but for the interposition of a divine Intelligence which, having produced the world, preserves it? In short Nature is under God's direction. This reasonableness and law-abidingness of Nature is Nature's great gift. Its rule crowns itself. Without it no item in its whole realm would stand, nor would the world itself. This reign of law was created with the world *for* the world; verily it is the mind and will of God. The Father of the Gods, said Plato, when he made the world and nature laid them under immutable laws. Each animal, each plant, each mineral, whatever is in this sublunary world, contains a particular Nature which maintains and orders it and its kind. This particular Nature, unalterable as it is, fits with all other particular natures. The whole combines to a universal Nature, which is sovereign, as it were, by the consent and unanimous sympathy of all. So it comes that Nature is ordered aright and lies under a fit and unfailing rule. Hence, seeing this, for the physician there is in man nothing whatsoever which does not come within the law of Nature, nothing whatsoever excepting only his knowledge and his power to will (cognitio voluntatisque arbitrium)"—in short his 'reasoning soul'.

This passage in collateral light we can look upon as something of a manifesto by Fernel. He was a physician surrounded by a society in which the praeternatural entered into every argument about health and disease and about every exceptional undertaking in life. Astrology and magic were forms in which the praeternatural imposed claims on the credence of both the learned and the unlearned, and brought its interpreters large

* *Therap*. i, praefatio; cf. also *Dialog*. i, 10.

earnings and repute. The Church officially discountenanced both, but astrology was too strong. At the very time when Fernel was writing the above, the Spanish Ambassador at the Court where he, Fernel, was Chief Physician, was reporting to the Queen about two heretics, the two captains of the reformed Church party in France: "The Italian lets not a day pass without taking the horoscopes and turning the screws in the life-size figures made by the Germans in likeness of Coligny and of Condé. Neither of them will live long." *

By Fernel's time the literary Renaissance had long been at full tide. Petrarch has been called the first 'modern'. He had been dead already a century and a half. Fernel felt with the enthusiasm of a youth the achievements of his New Age. These are in effect his words: † "The globe sailed round, the printing press replacing ten thousand scribes, paper replacing vellum, the world of letters open to all to read; sculpture, architecture, music, painting, abreast of the triumphs of antiquity. The recovery of the true texts of the masterpieces of Greek wisdom; learning and the fine arts blossoming afresh after a frost of thirteen centuries. This our New Age need not shun comparison even with the great times of old. It is for us to be up and doing." The vista of a great world opened by Christendom itself lies before Christendom. It was for Christendom to enter in and take possession.

We can feel that he is in message and ways of thought not too remote from today to compare with our today. We can understand and share his aspirations. He is, in time, hardly farther from us than are Shakespeare's characters, whom we all know and think of much as if they were alive today. We can follow him to some extent as a contemporary when he sets forth on his excursions into Nature. We can detect whither time has led us by contrasting his thoughts and ours.

With the Renaissance had come perhaps a fuller interest in Nature—fuller response to her appeal. The humanist revival overflowed as it were into the natural scene, not scientifically but aesthetically. Petrarch on the 'solitary life' with its human

* *Catharine de Medici*, by Paul Roeder, p. 411, London, 1937.

† *Dialog.* praef.

moods reflected in landscape, Aeneas Sylvius with his stories dwelling on the Italian woodland. The painter began to feel that cloud and hill and tree were of themselves worthy to delight even a palace. The living thing as such in a thousand forms attracted the artist. But the renaissance of Science was not come yet. It is said the humanist revival actually delayed it. The rebirth of Science was a later event. In Fernel's time there were portents truly—some cavilling at Pliny's botany. The caviller himself was in point of fact a superficial critic; yet the little revolt was in itself a sign of change. And some two years after Fernel's Dialogue was written a great thing in Science did in fact come to pass. A volume* dedicated by permission to the Pope, though afterwards put upon the Index, challenged the Ptolemaic system of the heavens. This book, from the death-bed of the old Polish astronomer, Copernicus, is usually taken as dating the beginning of the Renaissance in Science. As for Medicine, Medicine had still to wait to the next century when, 80 years after Fernel's death, its great revival would begin. Then William Harvey, the discoverer of the circulation of the blood, physician to our Charles I, restored to medicine, after 1400 years' abeyance, the master method of 'controlled experiment'.

In the above passage Fernel speaks with what Keats called "the gusto of the Elizabethan voice". He shared to the full the general culture and progressive outlook of his age. But he is medieval still in the knowledge of Nature at his disposal. He was steeped in the learning of his time. He represented, as perhaps no other so worthily could, the knowledge of Nature of his age. But in that respect the knowledge of the age was medieval still. The age had made little advance on the fine promise of the thirteenth and fourteenth centuries. His modernity of temperament and culture, it is true, help us to seize his readings of Nature and of man's place in it; but even so his reading, as we can see now, was often misreading. Nor was that his fault but his time's. He would otherwise not have been so characteristic and representative of his time. And always he had his age's virile spirit with a vast zest for life.

For Fernel man's liaison with the rest of Nature lay in this,

* *De Revolutionibus* etc. 1543.

that the life in him is in part the same life as vivifies all animate creation, yes, even plants. But with Fernel the conception 'life' and the conception 'mind' stand both for something separable from the concrete which manifests them. Nature is the principle which, under God, invests the concrete with them. Nature, this principle, must have something to work upon; as the sculptor 'must have bronze for a statue'. The something provided is matter. Fernel is so far Aristotelian. The concrete, every concrete thing, is analysable into matter and form. Nature has synthesized it out of matter and form. In that sense Nature is its cause, the cause which produced it, and maintains it.

When anything is created, it is its form only which then begins, and when the thing perishes it is only its form which disappears. Did the matter itself disappear the world had long since disappeared—used up.* There is a hierarchy of forms. There is a scale of matter. The ultimate of matter is beyond our observation; but reason by contemplation has arrived at four elements. Each is a combination of matter with form. Each is simple relatively to all concrete things. The four elements are earth, air, fire and water. They are not met with by us in their purity. Thus fire, sheer fire, is only in the celestial sphere above the earth. Earth without trace of wetness exists only at the centre of the earth. Pure air only in the empyrean above the sky. All four were capsuled within the ninefold shell of the Ptolemaic heavens. Each element is the embodiment of one of the four cardinal qualities of the world, heat, cold, dryness, wetness. Each element therefore has its diametrical opposite—its contrary. By itself it remains perpetually the same, but it reacts with its contrary. Everything inanimate and animate is an admixture of these four. Corporeal man is composed of them, and the food which replenishes him is composed of them.

The four elements had come down to Fernel through nineteen centuries. They are the 'roots of things' from Empedocles, come to Christendom *via* Hippocrates and Aristotle. They were now dogma. But Fernel is nevertheless great enough to treat them as not closed to discussion.

A point into which his Dialogue enters at great length is of a scholastic turn; "Are these elements substances or qualities?"

* *Dialog.* 1, 1.

That Fernel should enter into it suggests that at least in his case the classical revival had not completely ousted thirteenth-century science. He would be of course acquainted with the Arab masters of Medicine. Here he controverts Avicenna.

The Dialogue is almost silent about the speculation, 'atoms'. Fernel's reference to it comes from him a little oddly. It is that science has no place for speculation pure and unbridled. A remark justifiable enough, however, of the old speculative atom of Democritus. At the hands of Rutherford it as atom disappeared. The ancient atom seems to have been praised unduly by modern science. The more strangely so since we owe the Greeks what seems an earlier and greater thought than that matter is ultimately particulate. We would seem to owe to them the idea of 'matter' itself. Where others had seen Nature only as a manifold of divine and semi-divine happenings, magical and so on, to the mind of the Ionian Greeks there seems to have come early the conception of a something which formed the world of operation for these observable doings. Exploration of the nature of this something was, we can well think, almost the very starting point of Natural Science. That such enquiry was not at that time anything self-obvious is indicated by the reaction against it, on the part of Plato. But it had come to stay. Indeed it came to be regarded later as one of what William James styled 'commonsense conceptions'.

When thus established, the supposition that in view of the mobility and chameleon changes of nature this something should consist of subvisible movable ultimate particles of several varieties does not seem a thought very difficult or remarkable to come by, and it was early made. But to demonstrate it was difficult. It lay as a pure speculation for more than 2000 years. It does not seem to have been an influence with Newton. Newton's corpuscular hypothesis of the nature of light seems to have been drawn from his own experiments. Newton's treatment of vapours as being particulate seems to trace to Gassendi and Boyle's 'corpuscles'. When we reach Dalton the chemist, it is to Newton's corpuscles that his 'ultimate particles' historically attach. Only later did he call them 'atoms', reviving the old Greek fancy in name. The operation of genius had lain not in the speculation which invoked the atom but in the demonstration of its existence. The word has however already shown itself unsuited to Dalton's discovered particles; they are no longer ultimate nor indivisible.

The doctrine of the four elements seemed to Fernel on a more demonstrable plane than that of 'atoms'. It had been and was still one of the foundations of medicine throughout Christendom and Islam. For the characters in Fernel's Dialogue it is a liaison between their view of nature and their religion. It stood with them in some measure as a scientific declaration that the world was not, as some repeated, a purely material product by Chance out of Chaos.

"The Science of things", Fernel says in his Preface,* "was at first rough and turned only on what the eye or ear or other senses said. Effects were traced with little expenditure of thought. With time observation penetrated deeper, knowledge got farther from the merely sensual, and the abstruse was reached. Then first Philosophy was born in word and deed. Philosophy which seeks to trace in the manifold effects from causes and to bring all together. Much is however still obscure. We may smile at the old atoms and wonder how anyone can be persuaded of them—so many solid indivisible corpuscles which by collecting chancewise have brought to pass the immensity, the variety, the multitudinousness and completeness of the vast manifold of all the adornment of this world. Yet truly Democritus, could he return to us, would even now, as was his wont, deride us about our supposed elements. Not that I suggest there is nothing in the theory of the four elements. These elements seem established by all likelihood of reason. What I want to be clear about is that those, who make the four elements the cause of all which is, are greatly led away by their own arguments. The causes of many happenings belong elsewhere."

By that I take it he wishes to declare two things; one, that materialism in no form satisfies him. Almost at the time of his writing Padua was Averrhoist and materialist. The other thing, and the more remarkable, is that he treats explicitly as a hypothesis the long-sanctioned and generally accepted doctrine of the four proverbial elements as making up all corporeal substance. No one knew better than himself how it entered

* *Dialog.* II, praef.

into cosmology and geodesy, and that the whole structure of medicine whether Hippocratic or Galenical was built upon it. Nothing shows better his intelligent independence, open-eyed for departure from set ways. He was feeling through the old toward the new. Modern in his insistence that a long-sanctioned dogma, not demonstrable by observation, is hypothesis. Not modern in, nevertheless, proceeding to elaborate almost everything from it. The elements confer their quality on a compound by taking the quality with themselves into the compound. Our sense cannot perceive the elements as such. They are none the less material, and had we senses more perfect and means of analysis more delicate we should be able to isolate them and see them in a state of purity.* Yet after this avowal he treats them as of proved existence, and seems to forget he is building on hypothesis only. True, he did so in this case when all the world was doing so; and we must remember he had little else to build on.

At that time hardly more than in Aristotle's time did chemistry exist. It was going to emerge from the furnaces and stills and part intentional mystifications of alchemy, but scarcely until a whole century after Fernel. Broadly taken, it may be said to become intelligibly articulate only with Robert Boyle. Fernel was in his own way groping for it, but not in the professed alchemist's way. The Dialogue cites a procedure for the Philosopher's Stone, but only for the chief character to dismiss it, sanely enough, as fable. Fernel's approaches toward the great science of chemistry which was yet to be, were through his own acute observations of the human body. He likened some of the processes which have their seat in the liver to fermentation, though he was, I think, not the first to do so. Today the chemist knows that the liver is a very hive of ferments.

Let us follow him a little further in his acceptance of the four elements. Once endorsed he lets them take him far in his examination of Nature and Man. Ideas which are school-commonplaces of chemistry today Fernel has to labour to expound. He is at pains to show that the compounds which the elements make together are not simple mixtures; they are elemental unions. In their reciprocal action their qualities

* Riolanus, *Commentar. liber de elementis*, cap. 6, schol.

temper one the other. The result is a new body. The original elemental qualities persist but are latent. The diverse have become one. The elemental qualities modify each other to something new. Today this would be introductory to the theme of chemical combination. It is with Fernel a step toward the doctrine of the temperaments.

Eudoxus in the Dialogue is Fernel himself. The name doubtless follows that of the astronomer-philosopher * held in esteem by Aristotle—he who analysed mathematically the apparent paths of the planets. Fernel himself had studied astronomy with success. Aristotle's Eudoxus had written a book on Proportion; so too had Fernel.† Eudoxus, the character in the Dialogue, is a mature physician and savant. The scholarly Philiatros proceeds to draw him on the subject of temperament. In every composite body there are three collaborants, elemental matter, form and temperament. A thing must have form to be the thing it is; but its temperament is the key to understanding its ways and works. Analysis as furnished by a chemist of today would have told the scientist of Fernel's time nothing he desired to know. What was wanted then was how the resultant of the cardinal qualities came out. Their resultant was the temperament of the human body, the 'constitution'. Their perfect balance was an ideal never actually attained. It was an ideal standard against which to assess the concrete, and, among the concrete, man.

In the animate world, and in man himself, the four qualities characterizing the four elements were carried by the four humours. "Quatuor humores in nostro corpore regnant", sang the medical poem.‡ The blood was fiery and moist, the choler of the liver was the counterpart of elemental air, the atrabile or melancholy was of the spleen, and represented earth, cold and dry; the phlegm was the element water, wet and cold: it was

* *Nicomachean Ethics*, iv, 2. There he is mentioned as a hedonist. Theodore Gaza in a small book *Liber de mensibus atticis*, of which Fernel's own publisher de Colines had issued an edition shortly before [1535, Paris] the writing of the 'Dialogue', mentions Eudoxus' visit as an astronomer to Egypt.

† *De proportionibus*, Paris, 1528.

‡ *De Secretis Mulierum, de Chirurgia, de Modo Medendi*, Libri vii, Poema medicum nunc primum edidit Dr Car. Daremberg. Naples and Paris, 1885. 8vo. vi, 27, line 490. Thirteenth-cent. MS. in Bibliot. Nat.

chiefly of the brain and lung. Health is an approximate balance between the four—a balance that leans life-long a little toward one of twelve directions. It may lean more or less. Hence we have around us in our fellow-men the sanguine, the choleric, the phlegmatic, and the melancholic, and individual combinations of these types. We are each one or other of these types. Our type is the first thing the physician looks to read in us. Learned volumes* listed the distinguishable types of temperament. The very terms survive as commonplaces in all languages of Christendom. Each departure from the approximate normal balance was illness. But a contrary was a remedy and always to be found. Each plant and herb was a possible source of such. The Spaniards, while Fernel wrote, were ransacking the New World to find fresh 'contraries'. In every land for the disordered temperaments, the diseases of that land, Nature had planted in it remedies.

All disease whatsoever was embraced by the doctrine of the temperaments. This universality of claim was, however, questioned by Fernel and in this Dialogue. In effect Eudoxus says, "yes, misbalance of constitution is the illness, yet the cause is the practical point. There are causes we do not know".† Although he was without microscope and without chemistry Fernel was inclining toward a conception of plague and epidemic as poisons introduced into the healthy body and spreading there. He compares this unknown to the unknown something in a mad dog's bite. His mind was groping after what would still have to wait 300 years for discovery—the microscopic germ.

In thus asserting that there are natural causes of disease which were still to be learned Fernel was a lone voice amid his confraternity. Natural causes of disease still unknown! In the sixteenth century, when the globe had been sailed round, and the printing press had replaced 10,000 scribes. Incredible! The medical system of Hippocrates and Galen had been polished to perfection. Every disease is demonstrably an upset of temperament. What hidden natural causes could there be? Yet Fernel in the character of Eudoxus teaches that some diseases

* E.g. for a late example and in the vernacular, Jacques Aubert, *Des natures et complexions des hommes*, Paris, 1572.

† *Dialog.* II, 13.

are of a nature still unknown. Praeternatural, not natural? asks Brutus. But no, Eudoxus replies, he is thinking of natural, even though they come from the stars. Fernel is clearing his way toward a final residue of hidden causes. Would a residue of praeternatural remain at the end?

As to the make-up of living things he is much exercised by form. He elaborates his view. Form, as he thinks of it, includes two meanings. One is the gross sensible shape. Throughout animate creation the question of individual form exercises and fascinates him—how it comes to be, and what it means. The stuff which life inhabits is moulded by the entrance into it of shapes. This savours of the *Timaeus*; but the *Timaeus* is not usually any guide for Fernel. He had outgrown it. The study of form as he is thinking of it is that which Goethe later christened morphology. It is the form of which Aristotle as naturalist had such encyclopaedic knowledge, and used as a foundation. There are thinkers of originality to whom familiar everyday appearances do not grow stale. "The world is too much with us" has perhaps no stranger example than the taking for granted of the familiar forms about us of tree and animal and of our fellows. Aristotle read from 'form' a coherent philosophy of animate creation. He showed from it how they build up into a connected 'ladder of life'.

Contemplating that 'ladder of life', how close or how far did its animal rungs, in the view of our physician-philosopher, Fernel, seem to lie below the human? To Fernel doubtless the truest bond between animal and man would be that they both were creations of the pleasure of God. For Aristotle, animal and man had been of the same category of being; for Fernel, not so. The pious faith in him of itself disallowed that. As for a tie of actual kinship between animal and man, not even a suspicion of any such would enter Fernel's head. It becomes interesting then to know something of his positive thoughts about animal kind. In his estimation they seem to have stood nearer to plants than to man. But theirs is a mind ampler and different from that of plants. All animal movements he interprets as so many signs of mind. He did so even in the case of the humblest animal species. "The oyster and other shell-fish attached to the rock cannot move (i.e. locomote) but they feel and have imagination and thinking (fingendi cogitandique facultas) of a sort." * If pricked they draw away. I fancy Aristotle's opinion would not have been very different.† Fernel's bias was *not* to distinguish between "life" and mind!‡ With Fernel that the plant took nourishment from the soil—he did not know it did so from the air as well—was evidence of the mind within the plant. The general acceptance of a life-principle among whose endowments was mind made difficult the regarding any concrete life as not at once life *and* mind. "All animals have a sense of the pleasant and unpleasant, and that sense impels them to move toward an object or away from it."§ The sensation causes "an internal agitation which drives the animal to seek the pleasurable and the useful" || and to avoid the opposite. Such movement is in its nature inevitable and necessitated. He outlines some steps of the process as follows.

Images from an external object are drawn into an organ of sense, and thence transmitted to the "internal sense" within the brain. These, recognized for what they are by the internal sense, two subfaculties of that sense, namely memory and imagination—in the forepart of the brain—adjudge them pleasant, unpleasant, useful or harmful as the case may be. Upon that follows an instinctive impulse to movement (*appetitus*) which 'causes' a motion of approach to a pleasing or useful object or retirement from a displeasing or hurtful. The movement is operated ¶ by contraction (systole) of the brain forcing animal spirits from its front chambers into the hindmost chamber (4th ventricle), and thence down the canal of the spinal cord and out along the nerves into the muscles making tense those appropriate for the act. There was no element of choice on the part of the animal in all this. Freedom of choice of act belonged to man alone. When, some hundred years later, Descartes taught that animals behave as automata, his view was no great departure from this teaching of Fernel.

Not so long subsequent to Fernel, the naturalist, often

* *Physiol.* v, c. 9, p. 109. † *De generatione animalium*, i, 23.

‡ *Physiol.* v, c. 18, p. 125*a*. "Eadem (mens) naturae utens facultatibus corpus universum alit", etc.

§ *Physiol.* v, c. 9, p. 109*a*. || *Physiol.* vi, c. 12, p. 154*a*.

¶ *Physiol.* vi, c. 13, p. 156*a*.

a physician, set out to catalogue his realm of Nature by form, with a zeal not less because its view was but a part view. This classifying went on, and today it aims at an inventory of all the forms of life. In Goethe's time some of those engaged in it came to imagine certain ideal types toward which vast groups of individuals were, it was argued, striving, unconsciously on their part, as an aim of Nature. There was, so to say, a 'Universal' toward which the individual was an endeavour, an attempt. There was an imagined archetypal flowering-plant. There was an archetypal vertebrate. The view intrigued Goethe and he contributed to it. But it was illusory; and it led on the part of its enthusiasts to some distortion of fact.

However, a great result was in store later. It was chiefly from study of gross form that Charles Darwin recognized the 'ladder-of-life' as, being in fact, a family-tree. Of this there is no suspicion in Fernel. What does impress him is that life's series seems to have continuity. That the animal tribe merges into the tribe of plants. A sponge, who shall say whether it is plant or animal? Earth is still producing the lowlier forms from her own side. The ooze of rivers and of the seashore generates them. The dead carcass produces bees and insects. This acceptance of equivocal generation was general at the time. It was the view both of the folk and of the learned. It had patristic authority behind it. St Augustine of Hippo had taught that there existed from the beginning two kinds of seeds of life. The Creator had placed one set in animals and plants, that each might produce its kind. The other set were hidden in the elements and became active only under certain conditions. Buffon, the naturalist, two centuries after Fernel was teaching the same view.

The material could come from anywhere. But the form? With higher forms the form is of limited provenance. The form of the horse demands the horse to produce it. The form of the man is from man. That both of them should have two eyes, a head and four limbs says nothing to Fernel of any real community between them. Nature in its fertility at one moment threw off one, at another the other. Each was in the extreme literal sense a special creation. No history, in today's sense, lay back of either of them. Each was a creation unrooted in a past; a bolt out of the blue.

To Fernel the 'form' of the living thing is something separable from the substance, not merely in analytic thought, but in existence. He says that with inanimate things it is form coming to the material which makes it the individual thing that it is. With a living thing it is the form coming to it which not only makes it what it is but gives it life. In a plant or animal there are two collaborants, the four elements, with their resulting constitution, and 'form'. Form is at its simplest in the elements. With plants more perfect form supplies growth and reproduction. More perfect yet is animal form which covers sense and motion. Most perfect of all is man's—of all sublunary forms the supreme.*

This is a conception to which we have to accustom ourselves in Fernel. The body, despite its being of the four elements adjusted nicely to a 'constitution', has no powers of its own. It does not work; it *is* worked. What it does is the effect not of itself but of a tenant in it. Matter was for him and his time an inert substratum. Today it is a system of rushing units; a hive of self-maintained activity, a population of electric charges, spinning, attracting, repelling, circling a million million times a second. The very name and conception 'matter' today gives way to that of energy, a doing. The inert substance of Fernel, even where most static, is today changed to equilibria of torrents of movement. Its very continuity is continuity of change. Instead of separating form from matter, form and matter become inseparable and one—one and the same motion. It is so wherever matter is, in rock, or tree, or man.

Fernel in his plain pragmatic wisdom is, like Aristotle, loth to lose sight of the individual. This supreme form which is man's and shapes and completes him, is a total form over and above the forms of all the parts. It is a perfection but, Fernel adds, it is not to be thought of as a mere harmony.† A harmony is a compound of its parts. The total form is an individual, an indivisible unity in itself. It is a cause of harmony. It makes the parts of the body a harmony. This view forestalls what in psychology is 'figurism' today. It seems a little 'precious' as against the view that time held in store for the science of today.

* *Dialog.* i, 3, 406. † *Dialog.* i, 3, 407.

On this latter the tie between the activities of the body is that they all are just operations of the body itself. The body is one and individual, in so far as it *is* individual, because, and in so far as, its doings treat it as a common field. Those doings are therefore intrinsic and they are largely autochthonous. In all this the gap between Aristotle and ourselves is far less than between Fernel in his sixteenth century and ourselves.

For Fernel 'form' is a factor in the individual actually separable from his rest. When the living body comes into existence its form, whereby it lives, does not take part in it simply as a quality or property. The Arabs are wrong in supposing it merely a property of the material of the body. Alexander, that is Alexander of Aphrodisias, and Philoponus are right; Aristotle held it to be substantial over and above the elemental matter of the body.

In elevating gross form to this quasi-independent status in the living thing Fernel is following Aristotle. And he furbishes it with extraneous powers. To the student of science of today the conception is a little difficult to follow. I try to follow it faithfully as presented by Fernel. It strikes as naïve, and partly mystical, and strange to have been authoritative so lately as less than 400 years ago. We perceive that its source would more likely be a biologist than physicist. To trace it to the father of biology comes therefore partly natural. We can see how pretty a theme it would be for the old quarrel between nominalist and realist, and since the pith of this form is that it is individual and compels biology to be a study of individuals it is itself a challenge to the universal. Granting to it the vast implications which since Darwin it has come to have, the student of today is still left wondering at a certain crudity, as it seems to him, of the conception which crowds all the activities of plant and animal into the one attribute of gross form.

We see at once from the earnestness of the Dialogue this is for Fernel no mere question of words. On it depends the union between his scientific image of the world and his religious image of the world. On that union depends whether his world can be harmonized to one or not. Fernel is a convinced Christian; he is also one to whom what he calls "the philosophy of Nature", makes strong appeal. The form is no mere attribute of the body's temperament, for that is a product of the four elements which are matter. No, the form, having separate existence as it has, is itself a 'substance'. It is a substance from the stars, from the stars above the planets. Its provenance is celestial.

We may think that here despite a declaration in his Preface, Fernel, in his examination of Nature, has forsaken observation altogether. He would have replied, no; and true it is that still his endeavour is to be guided by natural truth. He continues thus:* "If there be one attribute which more widely than any other is evident as inherent in life it is warmth." Here he is simply reaffirming Aristotelian observation. He goes on, "in that we come across a great thing. A great thing like those great things which were found by the ancients. It is the innate heat.... A law common to all animal kind, an ordinance of Nature, is that they live by innate heat. While they live they are possessed of a heat appropriate to them. When dead that heat is extinguished and they grow cold. That is plain even to sense; it is heat sensible to man; a touch demonstrates it....It is however not so evident in plants. Yet in them no less than in animals it holds true....Further, the more sentient and active the animal the greater and more liberal the heat it has. If you ask a reason, think on the excellence of the sun, prime prince and controller of the world, favouring and forwarding every life that is. By its chastened heat it supports them from without in doing what life does. Now if its heat from without can so cherish, whereas cold checks, life, is there not within living things a heat which cherishes what they do, a heat which is even of the same nature as the sun's? Did not Aristotle well and truly say, and leave it written for all posterity, that heat is the condition of life? He defined death as the extinction of heat. Now this heat is the innate heat." Both earlier and later than his Dialogue Fernel wrote on the 'innate heat'. "The innate heat is a heat which can be observed to survive even in the coldness of the decrepitude of age. The coldness of old age dominates it is true the material fire which is in the temperament, but old age cannot, so long as there is life, overcome the innate heat itself. It is in virtue of this heat that the snake lives, although its temperament is cold. So too mandragora, and the poppy and all the herbs of

* *De Nat. Parte Med.* IV, I.

frigid temperament." Mandragora and poppy were herbs which because of their frigid temperament were held of value for relieving fever, fever being a case where an upset of the normal elemental temperament allowed the elemental heat, for instance in the blood, to run riot. Fernel continues: "Whence it is clear the *innate* heat is superior to *elemental* heat. Elemental cold avails against elemental heat, but it avails nothing against this more excellent heat which is the innate heat of living things. Therefore this innate heat is not of the same nature as fire. It comes from a source superior to fire.* In defining death Aristotle with the intuition of a master said the coldness of death comes not by mere overthrow of the temperament—not by surcharge of elemental cold, but by lapse of innate heat. Innate heat, vital heat, like light has no opposite. Light has no 'contrary'; darkness is but privation of light. Death is privation of innate heat, vital heat. This heat is not of the commingling of the elements. The body at death demonstrates that. Death occurs and still the body retains the structure and shape in all its parts. We recognize our friend, although his life is not there, and his heat is not there. The innate heat has fled him. It is not therefore traceable to the elements. They still compose the body. Therefore the innate heat—the vital heat—must have its source 'elsewhere'." So it is that Fernel identifies this substance, which is immaterial and universally present in living things as the carrier of their 'form'.

In physical science no phenomenon perhaps has proved more puzzling, and no conception has had so chequered a career, as that of heat. For Fernel it is a substance. More than a hundred years later chemical speculation elaborated it into a something which was lost from matter during combustion. But Newton and Boyle had held that it was a motion of the particles of matter, and proved it untraceable as mass. Thomas Young comparing it with light brought them together as comparable vibrations of matter. Today I suppose that may be rendered as comparably moving electrical charges. To examine the nature of heat was one of those several questions which Lord Bacon preaching the experimental method proposed to address himself to. We may say today that 'nature' as he called it has resolved

* Cf. *Dialog.* II, 7.

itself into movement; and heat into part of the ocean of movement of which the universe seems to consist.

We see Fernel asking his earnest questions, but he had not fully grasped that in the field of Nature he must defer to observation continually, and check each answer by that further form of question called experiment. Two kinds of heat! He was of his age; without verifying, he proceeds. Athirst for 'causes' he says, "This vital heat, which is the substance of vital form, what is its cause, its origin?" Then he renounces observation yet more fully.

Eudoxus of the Dialogue, that is Fernel himself, says,* "My friends, the question you put now is difficult. Aristotle in entering on his contemplation of Nature advises that nothing be advanced which the hand cannot touch, or the eye see. It is not possible always to be confined within those limits." The substance carrying vital form comes from beyond the stars, from the Prime Mover.† He is thinking of course in terms of a Ptolemaic Universe, the ninefold shell of heaven centred upon man. The stars belong to the revolving ceiling of the eighth sphere, next outside the outermost planet, Saturn, "the licensed evil one of God". Eudoxus reminds his friends that the starry sphere itself is an element, far other than the four elements we know—it is the quintessence.

He takes his flight. He soars into what Mr Russell has called 'mere thinking'. There is a celestial reservoir of the specific forms of life. Sol, the planet, is intermediator between it and earth. The sun pours down not only light but a bright splendour which dispenses the powers of heaven upon earth below. Thence comes it that the very bowels of the earth produce metals, the tribes of plants and certain animals, to wit, worms, flies, locusts, seashells, moles and serpents, though we are apt to think they arise spontaneously.‡ "But", cries Brutus, "man derives from man!" Says Eudoxus, "Everything ultimately is from God." The young Philiatros reminds Eudoxus§ that earlier he, Eudoxus, has told them from Aristotle that "the prime mover of the spheres is the head and front of all that is. Does not that put it alongside of God?"

* *Dialog.* i, 9.
† *Dialog.* i, 7; ii, 3; ii, 7.
‡ *Dialog.* i, 6, 7 and 10.
§ *Dialog.* i, 9.

A passage in Renan extols the grandeur and simplicity of Aristotle's conception, essentially naturalistic, of the Divine Being. "La profonde conception d'Aristote, ce dieu du XII^e^ livre de la Métaphysique, immobile, séparé, centre de l'univers, qui dirige et meut le monde, sans le voir, par l'attraction du bien et du beau, ce newtonisme métaphysique, si simple, ne satisfait pas les Arabes. Jamais dieu n'a été aussi déterminé, aussi isolé du monde que celui d'Aristote. Si l'on applique le nom de panthéisme aux doctrines qui craignent de limiter Dieu, aucune doctrine n'a été plus que la sienne opposée au panthéisme. Cette théodicée pouvait convenir à une école naturaliste comme l'école péripatéticienne: pour simplifier son objet et écarter tout ce qui ressemble à une hypothèse, le naturaliste voudrait faire à Dieu, une fois pour toutes, sa part bien arrêtée, et le reléguer le plus loin possible du champ de l'expérience." * Fernel, by the mouth of Eudoxus, gives briefly and impressively the attributes of Aristotle's 'deus', "sempiternus, immensus, incorporeus, individuus, non in mundo corporeo, sed supra hunc in excelso habitans domicilio, immutabilis, nulli affectioni subjectus, omnia movens",† etc. The conception plainly sweeps him along with a certain compulsion of appeal. His conception in this field was, however, to infer it from his writings and from Plancy's 'life', not reached by the same road as Aristotle's nor does it tally with Aristotle's, although under his influence. Fernel feeling the promptings of his faith the Deity he turns to is, so to say, less unhuman and less remote than was that of Aristotle. We may remember that, separate though their subsequent careers, Fernel and Loyola were of the same College, Ste Barbe, and of the same time in Paris, and that the head of Ste Barbe, Govea, to whom Fernel showed himself personally attached,‡ was the Govea who befriended Loyola in his student troubles. Fernel's writings, although writings of a layman, touched religion not rarely, and it is to be remarked there is nothing in them of, to quote the 'lay writing of a layman', a "personal God, who is present in the depths of the soul".§ This is apiece with his commentator's, Riolan the elder's, regret that

* *Averrhoes et l'Averrhoisme*, ii, 4. † *Dialog.* i, 10.

‡ Fernel dedicated his *Monalosphaerium* to him.

§ Juan Valera, in his English preface to *Pepita Ximenes*, 1886.

the 'Physiology' scants its application to religion. But, though all that was Arab was distasteful to Fernel, with him scarcely more than with the Arabs did the 'simplicity', as Renan calls it, of Aristotle's conception remain. That simplicity was inevitably complicated by the eastern orientation of Fernel's sacred sources.

Eudoxus replies to Philiatros:* "The Universe is twofold. There is in it on the one hand the visible, the concrete, the corporeal; on the other hand there is in it a world which escapes our sense, incorporeal. This other world is full of forms, simple, unmixed, dissolved. Minds free from all dimension and from all the corporeal; a world the most excellent and desirable dwelling place of God Himself and of the Divine." And this Supreme Being whose dwelling was so remote and far, even beyond Saturn the farthest planet, what then was the system by which He exercised his guidance and ruling over Nature and indeed the world? He was for Eudoxus and the interlocutors of the Dialogue no careless or indifferent Spectator of what He had created. For them no sparrow fell without His knowledge. "He who had created Nature also guided it; the boat He built He did not desert."† He steered and controlled it. On what system? Philiatros says, "By your leave, let us discuss this, you, Brutus, taking Plato, Eudoxus, Aristotle, and I contributing from Holy Writ."‡ They do so. In considering it they adduce from various sources what has been said about the organization of the divine administration of nature and the world. The conference runs on what we may call lines of authority. Authorities are accepted with a catholicity which seems a little disconcerting to a modern reader. Solon, Aristotle, Plato, Holy Writ, Virgil, Plotinus, Iamblichus, Hippocrates, Themistius, Dionysius, Theodoretus, Porphyry, Jerome, and others are cited with what there is nothing to show is not broadly equivalent respect. It is as if from pagan wisdom a confirmation were sought for Christian faith. The theme presently touches the thesis of a hierarchy of forms which under Supreme God share in the administration of Nature and the world, and of the place of the spirit of man in relation to this hierarchy. There are the

* *Dialog.* i, 9, especially. † *Dialog.* i, 10, 448.
‡ *Dialog.* i, 9, 443.

nine choirs of heavenly 'forms', graded downward from the Seraphim to the Angels. There is the guardian angel of Abraham, Zakiel; and those of Jacob and of Moses, Raphael and Metraton. There are the 'daimones' of whom Plato told and taught, and Socrates' own familiar 'daimon'. There are even the Lares and Penates. We are here far indeed from Aristotle himself and from that comment on him by Ibn Roschd "the proper religion of philosophers is the study of what is".

These spirits all were in their kind celestial. So is the 'spirit of man' in its due degree. "All that which aforetime God created, whether in the heavens or on the earth, He cherishes and rules. His succour and government of things heavenly is direct and at first hand. But animals, plants, and other things mortal, He administers by means of and through the agency of the heavens. For this delegation He has dictated to his ministers laws providing for creation and preservation of the things mortal ruled."* But the spirit of man partaking as it does of the nature of the heavens is not among things mortal and is directly under the governance of the Deity.

As to the nature of man, they agree it is not enough to know what individual man *is*; the key to much lies in the how of his becoming what he is. This of course does not signify that they have any inkling of what we now recognize as evolution. What they seek is how creation constructs the individual, perennial in type, and immutably repeated everlastingly within the limits of the created species itself. In the new individual at his beginning before he has drawn breath is his perfecting to be accounted a perfecting of material by drawing on potential qualities within it?† Eudoxus opposes such a view. Here the discussion grows heated and dramatic. Fernel has taken his three characters to an old battle-ground and, though two and a half centuries had lapsed since the old battle joined, the mention of it, here in Paris at least, still quickens the pulses.

Bishop Stephen Tempier in the famous decree of 1276–7 had obtained condemnation for the principal errors of Aristotelian and Averrhoist doctrine then currently taught in the University of Paris. The decree was directed mainly against Siger de Brabant and his rationalist Averrhoism, but some of the 'errors' con-

* *Dialog.* i, 10, 449. † *Dialog.* i, 7.

demned were an essential part of the 'orthodox' Aristotelianism of Thomas Aquinas and teachers in Paris. Bishop Tempier condemned 219 'heresies'. One of them was this 'individuation of matter', the subject of argument at this point of Fernel's Dialogue. The 'condemned articles', or to be exact 216 of them, were actually re-issued in Padua not a generation before Fernel's time, by the printer Mathias Cerdonis, about 1485.* The controversy was still alive then in the Paduan stronghold of Aristotelianism. Article 103 ran 'forma hominis non est ab extrinseco sed educitur de potentia materie'. This is what Eudoxus of the Dialogue writing 50 years later is arguing against. Eudoxus gains a dialectical victory over Brutus. No mere perfecting of matter will do. It is no mere entelechy. All *that* can do is to evolve what is potential in matter. But that will still be qualitatively matter. That is not enough, man has powers beyond those of matter. No, into the suitably prepared corporeal rudiment at the 40th day or thereabouts the specific form enters; it is celestial; it is from beyond the stars. Then indeed is there a new individual life. Until then it had been simply part of the maternal life.

Brutus in the Dialogue had in the meantime withdrawn from the scene—'his head is in a whirl'. Awaiting his return Philiatros proposes to sum up as 'epilogue' the argument reached. He does so briefly thus:†

"Everything that Nature begets is from its very outset made out of a material and a form. Of the two the form is much the more important, and constitutes the thing as we know it. Whence it comes about that the thing begotten is nothing stable or permanent. The form, whereby the thing comes into existence, cannot remain conjoined with its material for always. It joins it at some time, all at once in an instant. That is in the true sense 'birth'. Similarly, at some time, it will depart from it, and that is death. Before the form is called upon to enter it the material has to be got ready. Without that, the union of form with the material could not take place. This however is merely preparation. This preparatory organization is contributed by the

* *Articuli Parisius condemnati...sub bone memorie reverendo patri domino Stephano...anno 1276....* Padua, Mathias Cerdonis, 4to. (*c.* 1485).

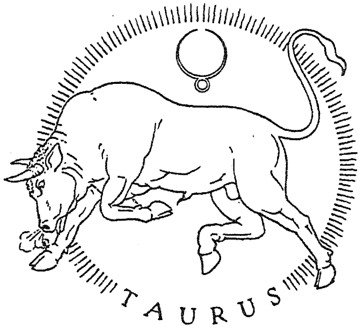
† *Dialog.* i, 7.

parent, whether by means of the seed or in some other way. This preliminary organization is of several kinds; the union of the four elements into a temperament; the proportioning of the body and its parts; the provision of the three corporeal spirits as agencies. All these proceed from the parents through the seed. When this process of preparation is complete, the form, the species, enters from without, naturally and, as you may say, of inevitable necessity. As for this 'form' it is utterly simple; in no wise is it built up of sub-forms. The faculties it possesses enable it however to carry out all the many things it has to do. Those who judge by sense merely and observe only immediate causes infer that the form obtains and is derived from potentialities in matter. But many valid arguments contradict that. The parent engendering another being of the same name and kind as he is does not create it. All the parent does is to be the means of the concurrence which unites the matter with the form. Above the parent is an Artificer more powerful and more sublime than the parent. He it is who sends forth the form, as by the breathing of a breath." "You have remembered it well," says Eudoxus.

In Fernel's orientation to nature and religion this then was more thinkable than that living matter after millions of years of, to adopt his own word, 'preparation', should unfold a new individual life from its own bosom.

But we glimpse from him in this how urgent a thing it was for him that the two aspects of his world, the natural and the religious, should be consistent one with the other. He is one who cannot be content to hold his beliefs about Nature and his spiritual creed apart the one from the other, in separate chambers of his heart. He must have them meet and rejoice together. It is a feeling which commends him to us; it would seem, too, a feeling which the cultured of his time shared with him, to judge by the large and lasting circle of the readers of his book.

But we notice also how, with the drift of science, knowledge has moved since then.



II

THE NATURAL AND SUPERSTITION

Come son fisse
Le stelle in cielo!

What spell is keeping
The stars so steady? D. G. ROSSETTI.

Videmꝰ moderno t̄p̄e multos lapides virtutibus olim sibi attributis deficere.

We see that in modern times many stones lack the virtues formerly attributed to them. PETRUS GARSIAS EPISCOPUS.

ad sanctissimū patrem et dn̄m Innocentiū papā viij in determinationes magistrales contra conclusiones Joanni Pici Mirandulani. Rome, 1489.

II

OUR sixteenth-century physician-philosopher, Jean Fernel, supposed in the body a something incorporeal. The material body did not work itself. The body was tenanted by a principle which made it 'live'. In respect of the acts of the body the corporeal substance of the body was as a tool in the hand of a craftsman, the craftsman being that incorporeal tenant of the body.* Fernel supposes this not only of man but of animate creation generally. In other words, there is throughout animate Nature a living principle which informs its bodies with life.

This living principle and its activities in the body, Fernel now proceeds to describe. His description purports to be a description of the principle. But the principle is incorporeal substance; it offers beyond that no data for description. We have seen already how when calling it in Aristotle's sense 'form' Fernel has settled that it is non-elemental heat, and has derived it from beyond the stars. The description he embarks on now resolves itself into an account of what it does, this principle of life, which has the body for its field of operation.

For this description Fernel refers to it consistently as the 'anima', with much the same connotation as is given in Aristotle's psychological treatise called the *De Anima*. If we try to render by one word that for which Fernel throughout uses this one word, we have to think what word, had he used our language, he would have used. Fernel did not write his treatises in the vernacular, we are therefore without that guide; but a French translator of his 'Physiologia' in the seventeenth century rendered his 'anima' by 'l'âme'. We may suppose that so too would he have done. A memorable holder of this lectureship has said of the word 'soul' that, like the word 'cause', it is out of fashion. But I think Fernel, had he at the time of writing his Latin been writing English instead, would, where he wrote 'anima', have written 'soul'. Perhaps that tinges what he wrote with archaism. But part of its interest

* *Dialog.* i, 4; ii, 1.

to us is its archaism, to assess against it our 'today'. And it may be that here the archaic is the better.

Fernel then calls his incorporeal principle of life which dwells within the body and activates the body and has come from the stars, the soul. It embraces life and mind. He says, disciple of Aristotle as he is, that it is of three kinds. The soul of plants, which is nutritive and reproductive. The soul of animals, which is sentient as well as vegetative. The soul of man which, over and above the vegetative and sensitive, reasons. Fernel is at pains to show that in man there are not three souls, but one soul. One soul which covers three grades of state and act. To follow his conception we shall perhaps best follow his words.

Each part of the body draws its nourishment by virtue of a faculty of the vegetative life-principle. That faculty imbues it with power to attract to itself, as it were by suction, fit material for itself. In the child besides nutrition the child grows. Are growth and nutrition one? Fernel observes that a child, while wasting with fever, will still grow in stature.* Therefore, he says, in addition to the nutritive faculty of the life-principle there is as well a separate growth-faculty. Indeed, each main type of action which he distinguishes in the body he identifies with a separate faculty of the living-principle. When he has done that and given the faculty a name, he goes sometimes no further, as though to name it completed his task of 'explaining'. He is, as he has said, out to trace things to their causes. A thing is not known, he says,† until its cause is known. But genuine explanation of the facts often evades him.

But his description gives us opportunity to hear his reading of certain broad aspects presented by living nature. Of the qualities of life the first and most fundamental—for it may exist alone, as in plants—is the vegetative comprising nutrition, growth and reproduction. Reproduction is of three grades:‡ spontaneous, so called, really due to the generative principle from the sun entering the earth; then, second grade, derivation from one parent, as in stationary plants and animals; then, the third grade, from two parents. As to the last, he denied that prenatal development—the human embryo was his instance—is

* *De Nat. Parte Med.* v, 3.

† *De Nat. Parte Med.* 1, praef.

‡ *Dialog.* 1, 8.

any 'individuation of matter'. In his denial he declared that he had Aristotle with him. But 'individuation of matter' was one of the counts* against Aristotle, when the University of Paris rose up and for a time forbade him.

One broad impression which Nature leaves upon Fernel, and so strongly that its impression upon him is repeatedly before his reader, is the continuity of all life. Not only the continuity of the animate as traceable through its various grades; the continuity also of the animate with the inanimate. The transitions are always gradual, by degrees sometimes imperceptibly small. But no, not always. There is the gap between man and all the rest. That constrains his wonder. To step from man to the rest is to pass from one order of things to something different enough to be another order wholly—and yet not wholly. That was what struck his contemplation as unexpected. Man was alone and yet not alone. There were myriads of things *partly* like him. Might that mean that they existed just so as to be of use to him? Fernel, as a physician, thought the plants and herbs if thoroughly searched would be found to hold in them a remedy for each and every human illness which is.†

This continuity, of the series of life, Aristotle had set forth. His ladder of life had steps from man down to the very soil. Fernel wonders whether that ladder upward stops at man. There are forms which are pure 'forms'.‡ Of one thing Fernel *qua* physician is sure; that man, whose temperament is of the elements, is within Nature. He is the greatest work of Nature. Fernel's interest in Nature focuses on man. That perhaps is why his interest in Nature has an intensity akin to the religious. Aristotle would be the high priest of his Natural religion were it not that no conflict must exist between his science, as we may call it, and his conception of the rest of life. His science and his religious belief must not conflict. That conflict would be intolerable to him.

In this book, as regards Nature, we are, it seems, overhearing Fernel's communings with himself. His preface to the King, to whom he was bound by personal attachment, says: "I have

* E.g. Articuli 190 et 214. (*Artic. Parisius condemnati.* 1276; printed by M. Cerdonis, Padua; *c.* 1485.) *Vide supra*, p. 30.

† *Therapeut.*

‡ *Dialog.* 1, 9.

long hesitated about publishing. This book contains things that thrown forth to a wide public may be mis-read." It had, in fact, for some six years or more been circulating in MS. among his friends. Printed, it found at once a wide audience. It is not merely a simple setting forth of the Aristotelian scheme of Nature softened to meet the perspective of Fernel's own Christian viewpoint. There would have been no particular point in such a work as that. That was already supplied in abundance. Further, Aristotle's light was no longer the star in the ascendant. We may take it that the urge was on Fernel's own part to deliver himself of his view of Nature and of Man in Nature. He was 45 when he wrote the book. They were views reached not merely in his study-chair but as a teacher of younger men in the Schools, and as a physician dealing with the sick and with the herbs and principles which can cure. All this he desired to set forth. And further, to deal with the occult as well.

Fernel was a skilled anatomist. He was an early advocate of practical dissection for the young physician. He was earlier than Vesalius, whose teacher he is sometimes called. The prestige of Galen was immense in anatomy as in all else. Fernel was alive to Galen's mistakes. Unlike Vesalius, however, he quietly corrected them without censure. Was not the ancient Master with his mistakes of 1300 years ago, Medicine's co-founder? Throughout Fernel's anatomy the reading of purpose in structure runs as connecting thread. For him the development of the embryo into the mature life is a 'becoming' initiated and guided step by step by a cause having its end in view. Today no longer in regard to Nature the *ratio rei* is the 'reason why'. Since Darwin, purpose in Nature's scheme occupies a sinecure. Nature harbours no ideal aims. What she does is to avail herself of opportunity.

Fernel had a wrong conception of the use and working of the heart, yet its anatomy conveyed to him the idea that it was designed for the office then attributed to it, and that the faculty of the soul which concerned itself with such things had executed its construction to that design. It would have been inconceivable to him that the eye were not a design by a beneficent Creator, Who aimed at conferring sight. A character in Hume's Dialogue remarks that the above inference from examination of the eye strikes the observer with the force 'of a sensation'.* It so struck Fernel. He tells us that the study of Nature is a study of final causes; divine intentions. With Aristotle the causation was immanent. With Fernel it was extrinsic. But for both of them nothing was made in vain. "Nature brings to pass always the best possible for each species according to the essence of that species." † Biology teems with examples of factors conspiring to a result advantageous to the organism whose behaviour they make possible. The human body exemplifies this. All living nature exemplifies it. The more intimate our acquaintance with any branch of biology the more numerous and ubiquitous such instances are. They obtain for small things as for great. The hairs at the entrance of a cat's ear are unlike the smooth fur around (see Plate V*a*). They make a strong criss-cross palisade which leans outward. To touch these hairs is to provoke a significant automatic act—'purposive' so far as that can be said of automatism. The touch sets up a violent rhythmic shaking of the head, and does so even when the brain is absent. A water-drop or intruding insect is thus flung out of the ear. We have seen the like when our dog shakes its ears and coat after a swim. May we not think the act shows why the strange hairs are there? The 'hairs' on a flower; they too have their meaning. May we not say that to each one of them its meaning attaches? That life is wonderfully contrived is of course hoary knowledge; it was the psalmist's 'wisdom of the body'; it was the Virgilian 'omnia plena Jovis', often on the lips of William Harvey. There was, for Fernel, a power outside the Universe which adapted means to its ends. The understanding of Nature was to be reached by tracing this. The problem before anatomy is, in Fernel's eyes, to read function from design.

As with Aristotle so with Fernel, the functions are the purposes, and the purposes are the causes of the body. Fernel says: "What Geography is to History such is Anatomy to Medicine—it describes the theatre of events." ‡ By 'events' he means the functions, that is, what the 'principle of life' is doing. The vegetative principle of life is common to plants and animals.

* Ed. Kemp Smith, p. 191. † *De animalium incessu*, c. 2.

‡ *De Nat. Parte Med.* II, praef.

In animals the principle of life over and above what plants do has sentient power, sentient faculties. Fernel passes on to these.

The vegetative faculties are diffused over the body. Not so the sentient. They are almost wholly localized in the brain. Together they are the 'sentient soul'. They must be localized; they must lie at a common meeting place for the incomings from eye and ear and so on. These incomings themselves are images from the perceived objects. Images which travel up the nerves. What is the nature of these images? Their medium is the spirits in the nerves. The spirits of the life-principle are three in kind. Throughout Galenical medicine they play a great part in the drama which is staged within the body. The spirits natural, vital and animal, have their several rôles. Yet they all of them are 'go-betweens', liaisons between incorporeal life-soul and corporeal body. To that part of the life-soul which is the mind, that is to the sentient soul and, in man, the rational soul, belong the so-called animal spirits. These animal spirits are for one thing the agent by which the mind becomes percipient of the external world. They are, too, the agent by which the mind moves its body, and so acts on the external world. These spirits of the 'anima' proper are generated in the chambers of the brain.* They are generated there by refining from the vital spirits of the blood; from the blood in the *rete mirabile*, a net-work of vessels under the brain. The vital spirits are themselves generated in the heart, the focal hearth of the vital heat of the body.

We are working round again to the stars. The incorporeal substance of the soul was we saw a spark from the stars, and now its agent, its spirits which serve it, are a refined essence from the innate heat, that is a celestial 'heat' imparted at outset to the heart. With Aristotle we are left sometimes in doubt whether the mind is or is not something pertaining to matter. With Fernel we are never for a moment in doubt. The mind is incorporeal, its substance is non-material. He should therefore, we may think, tell us how the mind as 'sense' receives the material images from objects. He does describe how from the eye 'images' run to the brain and are perceived, perception involving in the first place distinction from, and comparison with, other images. These images from eye to brain are 'animal spirits'. That is, are

* *De Nat. Parte Med.* IV, 11.

intermediate between corporeal and incorporeal, between matter and non-material substance from the stars. We are brought up short by that; there are today no intermediates between matter and non-matter. This is a difference between Fernel and today, a difference which cuts deep.

The conception of matter for Fernel was less precise. Nor is that surprising. A main task of physical science, restarting even before Galileo, had been, as we look back, the considering and testing by experiment the behaviour of 'matter'. Employing the usual licence to call 'natural science' tout court 'science', we may say Galileo changed science by asking not 'why' a stone falls but how it falls. Fernel was dead before Galileo was born. In Fernel's Latin the word is 'materia', with the general meaning attaching to it then. It denotes with him substance composed of the four elements. He often speaks of elemental matter as 'corporeal substance'. Substance with him embraces the incorporeal as well as the corporeal. Mind is incorporeal substance. But there are also intermediate-grades of substance. The spirits which help to work living Nature are among these—the natural, the vital and the animal. It is thought that Galen may have caught the notion of them from Plato in the *Timaeus*. Today the physicist tells us matter is granular, a system of protons, electrons, neutrons, mesotrons, etc. It is in that sense precisely described and limited. It gives no clue to anything except itself. It is silent of any nexus between it and anything else.

This gap of absolute disparation now bared between what he called corporeal and incorporeal was not fully present to Fernel's mind, nor to many of his time. He crosses it back and forth, without conscious difficulty. The transition compassed by sense from the material object with its train of material consequences in, for instance, the eye, to the further consequent change in the soul, the visual presentation, he passes over without a comment. He does so by means of the quasi-material which is also quasi-incorporeal. The animal spirits of Plato or Galen are for him the medium. They are a half-way-house between a thing and a thought. The same liberty of hypothesis allows him to treat on one basis all the 'faculties' of the soul, nutrition and mind alike. This helps him to preserve, what he is earnestly anxious to preserve, the unity of the soul. The working of such a process as 'secretion' is for him the act of a faculty of the soul, and reasoning likewise is the act of a faculty of the soul. For him their problems in so far are similar. The workings of the embodied mind offer for him no more difficulty than do any other workings of which the body is the scene. Each function of life is compassed by a corresponding 'faculty' of the 'living principle' inhabiting the body. Of this the mind is but one example among several.* It stands to the body in no different relation than do all other activities of the body. The disparation, for scientific treatment, which exists today between such a bodily act as secretion and an act of volition did not exist for Fernel. For him both were the work of an incorporeal principle resident in the body. When he traced the act of salivation back as train of causation the sequence ran:

α	Secretion	Fact verified by observation
	↑	
β, cause of α	Natural spirits	Inference unverified by observation
	↑	
γ, cause of β	Secretory faculty (a subdivision of the life-principle, i.e. of an incorporeal denizen of the body)	Inference unverified by observation

It is but an extension of this method when he deals with the mind. For instance, an uttered thought:

α	Articulation by lips, tongue, etc.	Fact observed
	↑	
β, cause of α	Animal spirits	Inference unverified by observation
	↑	
γ, cause of β	Motor faculty of the soul	Inference unverified by observation
	↑	
δ, cause of γ	Ratiocinative faculty (subdivision of the soul, incorporeal)	Inference not open to observation
	↑	
ϵ, cause of δ	Volitional faculty (the highest subdivision of the rational soul, incorporeal)	Postulate. ? Introspective

* Cf. *Physiol.* v, 9; vi, 12.

We see that with Fernel analytic classification is a way of arriving at 'causes'. A faculty is an unverified supposition used as an efficient cause. What he arrives at is that all our activities are those of an incorporeal essence. Nor is there difficulty about the incorporeal and the corporeal interacting. Specific intermediaries supply the connecting means.

Fernel thus treats mind as a theme within physiology. He devotes to it a full third of his treatise on physiology, a treatise which was the European text-book for much more than a century. If I may repeat, he included the mind and its workings within physiology not because he regarded the mental as an affair of matter. That was not his conception at all. He had no use for materialism. He considered the action of the mind as part of physiology, because for him all the workings which went on in the body were at source non-material, incorporeal. They were, along with mind, the acts of a spiritual incorporeal occupant of the material body. That occupant was the soul. The mental was one side of its activities. The human soul thus remained one despite its threefold aspect, vegetative, sentient and reasoning.

Fernel, though he followed Aristotle's distinction of three grades of soul, is not quite content with Aristotle's account of their mode of union. He admits that, as the embryo forms, it receives at first a vegetative soul regulating its beginnings of life. Later, with the coming of the sentient soul, this latter annexes and takes over the operations of the vegetative soul. Later yet, when the rational soul arises it assumes the function of its precursor, which merely prepared for it. Were it not so, he argues, man would be in part a plant, in part an animal, and only in part man. But man is man all through. As to how the rational soul absorbs the other souls, he takes* Aristotle's simile of geometrical figures beginning with the triangle and passing to figures more complex, arranged so that each contains potentially all that precede. The soul of man is therefore single. It does various things but is itself one. With this view no problem of the integration of the body would exist for Fernel, or if it did would be already answered. The integration of the body would be by means of the soul. As for an integration of the

* *De Nat. Parte Med.* v, 3; also v, 18 (old cap. 17).

individual soul + body, there was no need. The dominance of the soul precluded it and in itself sufficed.

Among Fernel's convictions is this, that the soul of the individual man is immortal. In the table of contents of his 'Physiology' is the item—"That our soul is immortal" "Animam nostram esse immortalem".* He supplies a physiological argument for this; that is, physiological in the sense in which Fernel conceives physiology. From nature we learn, tracing the derivation of the soul, that it is one, a unity. Then comes the dialectical point. The soul is simple. It cannot be split. It cannot be subdivided. It is an individuum; a spiritual atom. It cannot be broken up. It is utterly simple. If it cannot come to pieces, disintegration cannot befall it, it cannot perish. It is immortal.† This written 200 years later might have been thought traceable to Leibnitz.

For Fernel therefore physiology and psychology are not essentially different. They are not separate sciences. Aristotle had put forward the fertile thesis, of an activity, a mental activity, at the threshold of the percipient mind. By means of it the common recipient of sensual images, to use Fernel's term, compares and sorts and distinguishes the images. Without this juxtaposing activity the mind could make little of them. Fernel enters with zest into this doctrine of an internal *sensus communis*. With his customary brevity and force, he creates a picture‡ of a chamber where *simulacra* and *imagines* arriving from without crowd in upon the mind. It is there that, as seen in his picture, the waiting faculty of the soul, the mind, receives them and perceives them. It might seem natural, drawing such a picture, for him to figure for us the mind, playing its part in that reception chamber, as implicitly aware that it is 'I' or 'me'! An implied 'self' seems to attach obviously to the attitude of the mind in that hypothetical reception room. Such a view appears not to occur to or not to interest Fernel. For him the individual mind does not stand over against its world. It assumes no standpoint of itself as 'self', tacit or explicit. His psychology misses almost a half of what occupies psychology today. He does not notice the reference of mind to self, even when

* *De Nat. Parte Med.* v, 18; orig. c. 17 and tabula. † *Ibid.* 125.

‡ *De Nat. Parte Med.* v, 8.

insisting, as he does, on giving mind a special motor faculty, executant of bodily movements such as locomotion. An act does not seemingly bring before him any notion of a mental 'I' identifying itself with the act.

He is at pains, however, more than once to stress man's possession of free-will. It is one of his counts against the ancient materialists that they denied to man his gift of free-will. It is also one of his counts against astrology. But he seems to miss the relation that man's workaday thinking tacitly or explicitly has pivotal reference to his thinking self. Perhaps he took it for granted; but, if so, this insouciance, representative as he is, lets us understand the inability of the orthodox medicine of his time to enter into, let alone to treat, all that great group of ailments to which psychotherapy makes useful approach. Fernel had observed illness of that kind. His intellect is too keen and his experience too wide for it to have escaped him. He cites in his medical works some instances, and with shrewd penetration. But his question concerning them is rather, are they praeternatural? He is inadequately aware of the importance of the 'self' in the natural history of the mind. Nor would he get much help from Aristotle in this matter. He could have got more from St Augustine of Hippo. Of course it was still a century to Descartes and the famous 'cogito ergo sum'. That, looked at broadly, seems to mark, besides a parting of ways in philosophy, a starting-point in mental medicine.

Fernel deals presently with the rational soul. From what we have followed in him it is no surprise to find chapters in his Physiology treating of pure reason and the will. As we have seen, their inclusion as physiology, which might be taken to presuppose a materialist outlook, has with him no such meaning. They are faculties of the incorporeal soul as is every other action in the body. These are just faculties of the loftiest nature of that soul.

There is a passage where Fernel has resort to the old simile which likened rational soul and body to a pilot and his boat. He mentions it not wholly to endorse it. He finds inconsistency in restricting it to the rational soul only. In his endeavour to make himself more clear as to his conception of human death he himself offers a simile. It was something he wished to insist on, for he gives it twice.* He writes: "Look you, suppose a workman with whom all goes well. He is inside a room. To do the work which seems to him good he needs his tools. And he needs light that he may see. So it is with the soul. While within the trammels of the body in order that the soul understand and reason it needs a fitted place. If that fail, it works no more and quits." Fernel was probably the greatest physician of his century. Quite usually he was styled the 'greatest of the moderns'. We are told too of him, resourceful and somewhat severe in presence as he was, that the very note of his voice would change and soften when announcing, if that were to be, that the sufferer would recover. This simile of his just quoted seems to carry us with him to the bedside of the dying. There doubtless many times he stood with that homely poignant simile in his mind. We see how for him the problem which would then face him was to refit, to reillumine the darkening chamber which otherwise its harassed occupant would leave.

Other passages are a clue to what Fernel means by this simile. It roots us to his view of Aristotelian form. Man's 'form' is the most perfect. A form which is perfect, and has a wealth of faculties and functions, will not, he tells us, unite with material which is gross and simple. Did it do so it could not retain its perfection, because it must forego some of its functions, to which the coarse and simple material would not lend itself. The simile therefore avoids frankly likening the organs to tools of the spirit; it implies that the spirit has its own tools, not fleshly tools. The body and its organs become just a field for the life-soul to work in and on. The simile was then for Fernel no merely picturesque analogy, but a reasoned précis of the situation, as he, philosophical physician, conceived it, obtaining between body and soul in the hour of death.

Fernel is much exercised in the Dialogue about the praeternatural and sickness. Philiatros, hearing from Eudoxus that Aristotle in fact says little about the praeternatural, turns to the older physician: "Never mind", he says, "your experience shall tell us what part the praeternatural plays in medicine." Here the old Adam peeps through the renaissance

* *Dialog.* ii, 4, at end; *De Nat. Parte Med.* v, 17; *Physiol.* v, 18.

enlightenment of the sixteenth century. The physician was by tradition Nature's wizard and magician. Eudoxus replies, in a vein opposed to the professional orthodoxy of the time, "A number of the causes of disease are still unknown. Yet I think most disease is traceable to some natural cause. And happily so; for what derives from nature has assuredly somewhere in Nature its remedy and cure. But the praeternatural also does have its place in sickness. The physician must be on his guard however against supposing the praeternatural where it is not." * Brutus asks, "Where sickness is truly praeternatural do you say the remedy of it must be praeternatural?" † Eudoxus answers, "Doubtless. But there are remedies of supposed praeternatural power which are exhibitions merely of superstition. They are neither divine nor truly magical. They cannot claim their mandate either from temperament or from divine influence. The kind of thing they are? Well: a finger ring; a scrap of writing. How shall ink-marks on paper turn away disease? How shall such things cry aloud for help to God or to His spirits? How should mere words alone and of themselves avail against disease?" ‡ Brutus begs: "Tell me the words." Eudoxus says, "In the falling sickness words I have heard used are:

> Myrrh Caspar brought, thyme Melchior,
> And Balthazar brought gold;
> Whoso shall bring with him these three
> In the name of the kings of old
> Cures falling sickness by his piety.

For the cure of aching teeth there are the words:

> You combs and saws and harrows, you things
> with teeth, ease the pain in these teeth.

Again, for inflammation of the eyes a paper tied round the neck bearing the Greek characters R and A. Quartan fever is treated with a nail from a crucifix wrapped in sheep's wool. For splenic pain a fresh ox-spleen fixed over the place of pain, and the physician speaking to the spleen says, 'cure thyself'. To get rid of persistent cough, cough into a toad's mouth and cast the toad away." § Such a discussion, and written from the Faculty in

* *Dialog.* ii, 17.
† *Dialog.* ii, 16.
‡ *Dialog.* ii, 16.
§ *Dialog.* ii, 16.

Paris less than 400 years ago, is a finger-post showing the long way thought about such things has travelled since then.

In 1552 the famous physician Jerome Cardano, of Milan, physician and mathematician, was called to Edinburgh to a 'Prince of the Church', Archbishop Hamilton, Primate of Scotland. He stopped in Paris on his way. He has left recorded his contacts in Paris with 'the great Orontius', that is Finé, the mathematician, and with 'Pharnalius', that is Fernel. Cardano, like Fernel, had written a *De Proportionibus*, and had studied the courses of the stars and made calculations for them. But, unlike Fernel, he embraced astrology with enthusiasm. He was in that more typical of his time than was Fernel. He said of his own horoscope that it had foretold truly his whole career.

When Fernel and he met, he was just about publishing his astrological 'Aphorisms' with 100 specimen horoscopes. Travelling along the Loire on his way to Paris he had been busying himself writing a commentary on Ptolemy.* He was a man of native talent. In controversy the vituperative Julius Caesar Scaliger the scholar had found him a doughty opponent. Henry Morley last century wrote a 'Life' of him vivid with sympathy.

Cardano relates that in Paris he enjoyed contacts with Fernel and regretted parting from him. They would, we may think, have many things to talk of. Among them Fernel's dialogue on 'Hidden Causes'. The Paris issue of 1548 had been soon followed by a Venetian. As to astrology Cardano would, to judge from his autobiography, be impatient of Fernel's doubts. And Fernel, as we have seen, had little belief in natural magic. He accepted the magical where it was referred to in Holy Writ. He accepted it from the lips of Homer and Virgil. But he concluded it was a thing of bygone times. That was perhaps commonly thought. Thus Bishop Garcia: "in modern times many stones lack the virtues once attributed to them."† In the matter of magic Cardano, a wishful nature, would have to put up with Fernel's

* *In Cl. Ptolemaei IV de astrorum judiciis, vulgo Quadripartitae Constructionis, libros commentaria,* folio, Basle, 1554: dedicated to John Hamilton, Archbishop of St Andrews, whose horoscope Cardano drew. Among the 'sample genitures' in the book are those of Edward VI, Henry VIII, Giovanni de Medici, and of Christ, and of Cardano himself.

† Lynn Thorndike, *Hist. of Mag. and Expt. Science,* iv, 500; 1934.

scepticism. We can, if we may venture so far, helped by Cardano's Autobiography,* imagine converse between them to be somewhat argumentative.

Cardano, voluble and somewhat temperamental, would we can think do most of the talking. "Of those, Fernel, who read your book on Hidden Causes as many tell me you believe in the Philosopher's Stone as tell me you do not believe in it. We all know you a disciple, a Christian disciple, of the great Aristotle. So too am I. You remember what the pious Eusebius said? Rising from his porings over Aristotle, he cried, 'I am like a fisher after sepia, the great squid. When I think at last to have him, he fires me an ink-cloud, and is gone—he and his conclusion! And I know not in which direction they went off.' Your judgment, my dear Fernelius, on the Philosopher's Stone is like Aristotle's on the immortal soul. For me the Philosopher's Stone is simply lust after gold. The elements, although *my* elements are not *your* elements, cannot be juggled with so as to change, my dear Fernel. If so they would not be elements."

And Fernel might reply: "To those who weigh them, Cardano, my words are clear. Do I not in giving the recipe of the Philosopher's Elixir call it a fable? But you will be with me when I say the so-called fermenting of metal to gold is of less import than is humoral fermentation. The old Arnaldus truly had there a new thing and a great. Why, the second decoction itself, the hepatic decoction, is a fermentation."

And Cardano had broken in: "That may well be. And there is that Bombastus; he persuades the foolish they have a goblin, an Archaeus, in their stomachs which only he can treat. Let him assuage the Archaeus in his own stomach, for it has a deadly drought. Incomprehensible? yes; he shouts two contraries in one breath and with his next two more!"

"In that way", remarks Fernel, "if he continues he will sometimes be right." "Basta", cries Cardano, "the man is ignorant." "Then likely enough he will make cures", says Fernel. "There ignorance may help. It has confidence in itself and that in turn wins confidence from others. I have seen the so-called magical work a cure when helped by confidence. Magic is not

* *De Vita propria liber*, 1575.

what it thinks itself. Its source of power is faith. Is that divine or magical, Cardano?" Cardano had replied, "Ah, my dear Fernelius, I know you to be sceptical! I am with you about the alchemist's stone, and much else that is nonsense. But the magical! Why I know it at first hand. Who was he, I ask you, who sold me that copy of Apuleius? He seemed a man! I was in my 20th year. In Pavia it was, near the Accademia. He sold it to me and straightway was gone. I was foolish to buy the book. It was in latin. I could not read latin. I had been only to the junior school. I bought the book for its pictures. That night I looked it through but of course decipher it I could not. Next morning when I woke I looked within it again, and lo! I found myself proficient in latin, fully proficient, I could read and write in it and discourse in it—as I do today. Who was he I ask, who sold me that book in Pavia by the Accademia? The magical, Fernel; I know it at first hand and many times have met it."

"Ah, Fernel, you are sceptical too about the planets. Nor are you alone. There was Pico, there is Sambucus and, Heaven take it, Scaliger, and I think, through you, your own Plancy. But, wise Fernelius, surely the planets influence the humours and spirits of our bodies! How then can they fail to influence our acts? As there are causes of illness which are natural, so are there causes which are praeternatural. The starry heavens play their part in both." The meeting between them resulted in no conversion either way; and so we may leave them.

Trusted physician of his age, we see Fernel surrounded by a world of magic and superstition. Even he can speak of the 'truly magical'.* For most, even of the cultured of his time, in Nature almost anything might happen. What had come down from Egypt, Greece and Rome and from the Arabs, along with truth contained an overplus of untruth. Such as it was, it was still largely unsifted as to the superstitious. The later Middle Ages did, in some measure, grow more critical. Magic indeed had become more critical of itself. It looked to experiment; but to experiment little guided as yet by any vision of law. Against this darkness Fernel stood, a dignified figure, trying to observe and trying to distinguish between the true and false.

* *Dialog.* ii, 16.

Also a pathetic figure, because his means for distinguishing between them were so scant. He had his single-handed observation, and his honest submission of tradition to the general test of reasonableness. He judged as an observant man out to know the truth. And there were others with him, though they were few.

To return to the Dialogue: Brutus exclaims, "Then you don't believe in these things. You declare these only natural things and of a kind powerless against illness?" * Eudoxus answers, "I say that. But there is much of which we are ignorant. Above the visible world there is a world not accessible to sense—reachable by excogitation only. There God is, and there the spirits He directs. Thence comes much that is helpful or harmful to our mortal world. He covered earth with eclipse whilst Christ was suffering. For Joseph He smote Egypt with famine, flood and pestilence. He stayed the motion of the heavens for Joshua and held the sun at standstill." † We see Fernel's rationalism here limited by his religious orthodoxy. He goes on: "There is, too, Plato's Cacodaimon, the unresting enemy of mankind, who by licence of God inflicts sickness; such sickness *is* praeternatural, but only in cause. That there are men who can do ill by evil powers like Cacodaimon I myself cannot think. I cannot conceive a beldame inflicting harm by a look, though I know Virgil and Pliny say so. Magicians we know there have been. Christ's apostles beheld with wonder the works of Simon Magus. Pliny asserts Nero could work magic, but more probably I think, he dabbled in poisoning. It is said that today magic can put an evil spirit into a man. I once was called to a youth who even seven times a day was taken with struggling so that four servants could hardly hold him. Between whiles he was sane and knew all around him. He was thought to be possessed. In my view it was epilepsy, which is not from a demon but from the brain acting on the nerves. I ordered clysters, baths and rubbing. But if magic and the praeternatural were the cause the remedy should be praeternatural—prayers and offerings. But I believe that today magic can at most cause the semblance of a disease. A sufferer may none the less be persuaded into thinking he truly has a disease. I have seen a paper with some writing on it strung round the neck heal such illness of the whole body and in a

* *Dialog.* ii, 16. † *Dialog.* ii, 16.

single night. I have seen a fever banished by pronouncing a few ceremonial words. But such remedies do not cure for long. We have to be on the watch. Illness can be fictitious, so also can cure. Human nature is perverse." *

We have a glimpse here of Fernel as forerunner of suggestion-therapy. We note also how distasteful to him was empiricism. With his zest for tracing 'causes', he distrusted everything for which no 'cause' was assigned. But this search for the praeternatural in medicine goes with the scheme in Fernel's mind of a world of incorporeal beings. Beings 'between earth and heaven'. A hierarchy of domination under God. They are entrusted with the administration of many things in the sub-lunar world. Corroboration of their scope and status he obtains from Plato and others, with citations of some length. They are of incorporeal substance wholly. Man is akin to them in part. He was deeply impressed by Plato's mention of the 'familiar spirit' whose company Socrates had experienced from boyhood. Such spirits have, he tells us, nothing to do with the entelechy of Aristotle. That was a perfection of material only.

But Fernel was surrounded by yet another great superstition besides that of natural magic. Another superstition founded on Nature, and more exalted and refined than magic. A man in those days—and in classical antiquity no less—might be sceptical about magic and yet endorse astrology. He would appraise it as a science. To Fernel's time it had come down from antiquity without loss of prestige, as a learned study of the stars. It amounted to a cult. It accredited certain aspects of the heavens with praeternatural influence on man's circumstances and doings. It had its developed symbolism. It was a false mysticism which satisfied that craving for the mystical which forms a part of human nature. It demanded observances. It enjoined rites. It was taught and practised by the initiated. It was in effect a quasi-Natural Religion. We must remember that in those times cosmology was expected of religious doctrine to an extent hardly looked for from it today. If a religion can exist without moral bearings then astrology was a Natural Religion. It was in Fernel's time the Natural Religion of the classes and of the 'liberal minded', of the 'intelligentsia'.

* *Dialog.* II, 16.

There had been in the Middle Ages and there were in Fernel's time some who regarded magic as compatible with and even confirmatory of Christian doctrine. One of the famous 900 theses of Pico della Mirandola's, had been "No science gives more assurance of the divinity of Christ than magic and the cabala".* But the Church repudiated that thesis.† More widely held was an endorsement of astrology as part of Natural Theology. There were those who taught that theology and astrology agreed by reason of a divinely established relation between them. Astrology was thus in so far 'theologized'.‡ A ground its appeal took was that it was a system which set forth the share which 'fate' assumes in human affairs. It accounted for the part played by Fortune in the human tragi-comedy. Each successive human hour was the scene of a struggle for upper-hand between powers beneficent and powers malevolent; their struggle was over man's life and man's soul. Time fed both sides with opportunity. Time brought the inescapable vicissitudes of 'toward' and 'untoward'. Man by the help of the beneficent powers could rise superior to Fate, and there foreknowledge, attainable through astrology, could in its measure enable him to avoid being every moment at the mercy of circumstances unforeseen. Yet he was in the main a creature of circumstance. And there were powers ceaselessly on the watch to beguile him as opportunity arose; to turn mischance to evil account against him; to transform even the propitious into a temptation. There was conflict over him between Good and Evil all his days and nights under the sun and stars. A famous title-page§ of that time (see Pl. I) expresses this perhaps as vividly as any page of text. It portrays man passing his hours in a walled city and on its stream. An astrologer in the foreground reads an astrolabe and a human figure holds a giant dice-cube. Overhead above the clouds the celestial sphere, belted with the zodiac, is carried by Time on

* L. Thorndike, iv, 497.

† Petrus Garsias, *Determinationes magistrales*, Romae, Euch. Silber, 1489.

‡ See for instance *Astrologie Theologized*, by Valentine Weigelius; London, 1649. This is a translation of a work by a German (1533–88) published posthumously.

§ *Triompho di Fortuna di S.F. (Sigismondo Fanti), el quale tratta delli accidenti del mondo, si per scienza naturale come per astrologia da M. Vannullo. . .fedelmente esposto.* Venegia, 1527. 2vo.

PLATE I. TITLE-PAGE FROM FANTI

an axis turned at one end by an angel figure, Virtue, and at its other by a demonic shape entitled Voluptas. A seated figure of Religion, wearing the triple tiara, attended by two angels, watches above the sphere. Below in the city a great dial on a tower carries the cycle of the 24 hours. This title-page would in all likelihood be familiar to Fernel.

Astrology was at that time the most mathematical and probably in general opinion the most regarded branch of natural philosophy. So far as natural philosophy could claim relation and affinity to theology, the 'Queen of Sciences', the science best qualified to do so was probably in current opinion astrology. This prestige gave it the more assurance as a contribution to natural religion. Lending itself further to the claim was the view, not rarely held, that the heavenly spheres were animate. The movers of the spheres were 'intelligences'. If to worship them savoured of idolatry that objection could be evaded in all sincerity by thinking of them as angels in the service of God. Pico della Mirandola in his famous rhetorical attack had criticized this. "If astrologers believe in anything it is in the Planets, not in God." As to the objection that astrology was fatalist, astrology replied with its maxim "the wise man rules his stars". Perhaps it is in some such reference that Shakespeare's Cassius says, "The fault, dear Brutus, is not in our stars, but in ourselves." The speech need not imply on the part of Cassius a disbelief in astrology; it is sometimes read as counsel to resort to it.

That the heavens were animate was a theme treated at some length by Wimpina, the cleric who in Fernel's life-time was Rector of the then newly established University of Vienna. He followed up his treatise on the nobility of Christ by turning "to the theme of the nobility of the celestial spheres and their movers or souls as a fitting complement to the other".* Kepler the astronomer and astrologer, even in the next century after Fernel, wrote of the souls of the planetary spheres.

Cultured knowledge lent itself in the time of Fernel, four short centuries ago, to these mystifications. Knowledge truly able to criticize them was barely as yet shaping itself. It had to wait for Galileo and Harvey. Magic and sorcery were part

* L. Thorndike, *History of Magic and Experimental Science*, iv, 268.

of the belief not merely of the common folk but of the cultured, especially those of 'progressive' view.

The Church condemned sorcery and magic; but as for astrology, cardinal after cardinal had his astrologer. "At Rome", said Savonarola, writing about the year Fernel was born, "no prelate, no rich man, but has at hand an astrologer to say whether he should ride forth or do anything. No one takes a step in life without his astrologer." * Cultured liberal opinion was inclined to accept medical astrology as the climax of scientific medicine.

If we feel surprise at meeting what today may seem such gross credulity, we have to look at it within the setting of its time. For instance there then reigned unchallenged the great sense-illusion which lets us think we walk a stationary earth, while sun and stars move around us. From his supposedly fixed place man looked at the heavenly spheres enclosing him, and supposed himself the focus of a nine-fold heavenly shell (see Pl. II). Around him the seven planets—and sun and moon were of them—journeyed without pause. Their pivot and fixed point was man. To influence him seemed the object of their being. The sun gave him light and warmth. The moon mitigated his night. Over him marched each year the procession of the constellations. With them they brought the seasons for him. They typified, as it had seemed to the Stoics, Fate's wheel. Over man's head, under his foot, to either side of him, the macrocosm revolved. Its influences rained in upon him. The sun steeped him in day and bequeathed him night. It also lent him, as Fernel has told us, innate heat, the very essence of life. As for the moon, its cycle governed ocean's rhythm, and the rhythm of the life of woman. The human microcosm and the macrocosm of the spheres reflected one the other. Between the two there plied a constant commerce of 'causes' and effects, an unceasing circulation of elements, of influences and of souls.

The macrocosm fulfilling its vast circuits and epicycles of meticulous precision, its risings and its settings, its movements within movements, was an immense body fashioned after the likeness of man's body. Inward it faced man the microcosm, concentrated prototype of creation, epitome of the Universe itself. Macrocosm and microcosm were shot through with

* Villari, *Storia di G. Savonarola*, i, 169.

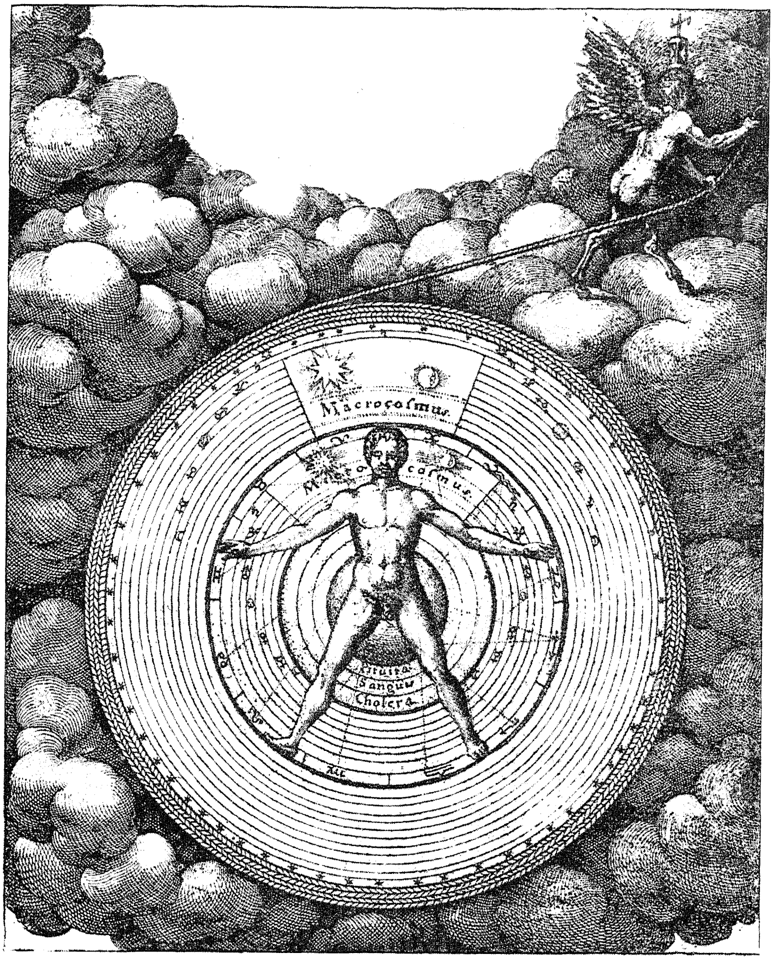


PLATE II. MACROCOSM—MICROCOSM FROM ROBERT FLUDD (1617)

influences each of the other. Each and all of the planets exerted 'powers' on man. Why else should they wheel unceasingly around him?

The planets, what were they? We have to disabuse ourselves of the supposition that they in Fernel's day brought to mind anything like what we think of them today. And we have also to remember that of all the shining fires inhabiting the heavens the planets moved most and fastest. Deep down among human intuitions is one that spontaneous movement means life. Our kith and kin among the animals entertain it as well as we, though for them 'life' is, of course, an unconceptualized thought. We know from ourselves that the indirect field of sight will see what moves when it fails to see what does not move. Our horse may shy at a blown leaf on the roadway, not at a still one. The frog snaps at the fly that moves, but not at one which is still. The vine-tendril never lives so vividly as when at the cinema its clasping is speeded into visible movement. When the cardboard puppet dances it becomes thinkably alive, and Don Quixote's irruption at the puppet-theatre becomes intelligible. The biologist knows this intuitive inference as native, even to a primitive mind. Movement accepted as spontaneous implies living. And the motion of the planets seemed to be spontaneous. Their movement told men that they were alive. All stars might be alive, but of them all the planets most so. The other stars were 'fixed', that is, relatively to each other did not move. Lorenzo's words to Jessica "heaven is thick inlaid with patins of bright gold" expressed common opinion that the stars were fixedly set, some more recessed than others, in the 8th sphere as in a ceiling. They were like bright studs on the interior of a cathedral vault. The majestically moving roof of heaven carried the fixed stars with it as it went. Leonardo da Vinci's curiosity suspected they might be disposed in a polygonal pattern, and searched the night sky for it, in vain. That the stars were fixed made the more impressive the ceaseless journeying of the planets with their several hastenings, retreatings and delayings.

Agostino Nifo, the Averrhoist in Italy, where Averrhoes was still a vogue, maintained the unity of the human intellect in the meaning that there was but one intellect and it men shared in

Woodcut from Nifo [Agostino], Bologna, 1520. Two dignitaries receiving from an astrologer's messenger the prediction of the universal flood for 1524.

common. He was Fernel's elder contemporary, and outlived him. His teaching* as to the planets was that the only separate individual intellects were those of the planets. In short educated opinion of Fernel's time commonly regarded the planets as alive and besouled.

Fernel stresses how Plato taught they were divine beings; Plato, he adds, fell little short of being a pre-Christian Christian. Fernel, if he knew that Anaxagoras had said "the sun is a great hot stone", would probably have discounted that; he had no use, he has told us, for unbridled speculation. To think of the planets as we think of them today, masses neither alive nor, it would seem, abodes of life, would, we may think, have saddened Fernel. This earth, a speck, seemingly an infinitesimal side-show, moving among millions of sister bodies and cut off from even the nearest of them, by spaces unbridgable by life, might have seemed to Fernel a heavenly rebuff, a divine rebuke. Earth's isolation, as we know it today, might well have saddened him. The telescope had not yet come. When it came, the first thought it brought was, "Are they populated, those other orbs about us?" Fernel's first question might well have been even more assured: "What are their people like?"

More precise knowledge of physiology and of the physical conditions of the planets than the mid-sixteenth or even the late eighteenth century possessed was needed to discountenance the view that the planets were inhabited. The type of their inhabitants was a topic of polite conversation in the 'salons' of Paris in the seventeenth century. As instancing the essentially local and earthly make-up of our mind, of interest is that the talk mainly was conjecture as to the type of man which would be found in the Moon, Mars, etc. Kant the philosopher, in his contribution to the theory of the heavens,† launched in the latter half of the eighteenth century a view of the planetary inhabitants. He divided them into classes according to their distance from the sun. The inhabitants of the Earth, Venus and Jupiter should form a series graded by the difference of their solar distances.

"The matter of which the inhabitants of the different planets are formed, and no less the animals and the plants of those same

* *De intellectu et daemonibus*; 1518.

† *Sammtl. Werke*, 1, 207. *Theorie des Himmels*, 1755 (Hartenstein). *Anhang. Von den Einwohner der Planeten.*

planets, must be, in general, so much the more subtle and delicate in nature the more remote their distance from the sun; and so too the elasticity of their fibres and the disposition of their structure the more perfect." This, he adds, is no mere conjecture of finalism. It is in accord with the calculations of Newton. It must apply also to the mental faculties of these inhabitants. The excellence of their 'thinking natures', the rapidity of their ideas, the lucidity and force of the concepts which they derive from external impressions, etc., in short the degree of their perfection, is "in proportion to their distance from the sun". Perfection of body and mind increases in the planets from Mercury to Saturn "or perhaps still further (if there are other planets)". "If the idea which man can form of the beings of highest intelligence who inhabit Jupiter and Saturn excites his envy and humiliates him in view of his own low estate, he will console himself by reflecting how much, in the planets Venus and Mercury, the nature of the beings there is lower than human nature. What spectacle more worthy of admiration! On the one side (Mercury) we see thinking creatures among whom an Esquimaux or Hottentot would be a Newton, and on the other (Saturn) beings who would regard Newton with the same astonishment as they would a monkey."

For Fernel, however, the stars objectively were just shining points which traced their cyclic movements round the earth with mathematical punctuality. More practised in watching them than were most, even in that age of sky-watching, he knew their risings and their settings. He had devised a special astrolabe. In his very first approaches to medicine astrology had fascinated him. He had published his book on proportion to facilitate the calculations. To know the influence of the planets, their conjunctions, their oppositions, their reinforcements and their cancellings on human health and sickness, was one of the first arts in which he practised himself after entering on medicine. There were astrological compendia of medicine much read in Fernel's time. One had come down from Arnaldus of Villanova, the thirteenth-century physician.* Its subtitle runs, "Con-

* *Hec Sunt opera Arnaldi de villa Nova que in hoc volumine cōtinentur.* ff. 398; 2°. Lugduni per Franciscum Fradin. 1504. The copy in the Royal Society's library has the book-plate of Bilibald Pirckheimer, the patron of Albert Durer.

cerning the judging of sickness according to the motion of the planets." As for its doctrine: "All elemental motions, those of the air as well as of our bodies, arise from changes in the astral fluid under the motions of the planets." The planets in their course move through the houses of heaven, and as they do so each for the time being lends something of its spirit to the house in which it is. Moreover, in each house in turn the planet traversing that house is changed somewhat in spirit by the character of its habitation. Of the planets, Jupiter is benign, friendly to man. Venus is an influence on generation both in man and woman. Mercury is unstable, a promoter of change. Mars resembles his prototype of ancient Olympus. Saturn is evil, the Cacodaimon of Plato. There is affinity between him and the melancholic. He is the enemy of joy, the ally of pain and death.

The houses these characters moved through, the twelve houses of heaven, were chambers of fate, in definite respects propitious or malign. The first house, one of the cardinal four, was favourable for startings, as for life's starting, birth; the second was hell-gate, the pit of woe. The third, under the sign of Gemini, was the place of brothers, of friendship. The eighth was the house of death. The eleventh of the good spirit. The twelfth was the house of hatred, the place of Plato's evil one. To the astrological eye the planets as they swam across the night, now lingering, now hastening in the successive chambers of the zodiac, resembled characters in a stupendous drama, grouping themselves and regrouping themselves on the celestial stage. They were fateful figures in the macrocosm encompassing man. Man, the microcosm, went below them almost as their puppet. Fluctuating tides of influence from the macrocosm, qualities and effects and causes, swept over him. In the opening part of his physiology, Fernel speaks of the necessity "to look upward and observe the wheelings of the heavens and the stars (Pl. III) and the influences which proceed thence and control this lower world".*

In Fernel's day, with the learned and the studious the question was not so much whether or no astrology was true, but rather whether all of it were true. The earnest physician had to orientate

* *De Nat. Parte Med.*, praef.

himself in regard to this. That the natural in the stars and planets touched the natural on earth Fernel held and taught. "The stone selenite holds the image of the moon even to her very phases. The magnet-stone points to the pole-star." "These are dead things," says Brutus, "do living things likewise draw influences from the sky?" "Yes," says Eudoxus, "some from the sun more, some from the moon more. The chicory's flower watches the sinking sun. When the moon is down the ant lies still, but with the moon's full runs busy.* Right it is to scan the heavens for help to nature underneath."

But Fernel, despite his early enthusiasm for astrology,† became, as years went by, gravely disillusioned in respect of it. His fervour for it had been prior to his entering actually on medical practice. He was at that time a mathematician and, as a young physician, reading theoretical medicine. Later had come to him first-hand care of the sick and daily charge and responsibility at the bedside. And in no ordinary measure, for his practice became very large. Then with his knowledge of the planetary sky and the starry houses and with his mathematics he was equipped, as were few, to read the astrological soothsayings and check them against fact. He proceeded, at first with every confidence in them, to compare what they told with what passed before his eyes in the sick room. He was not one to feel lightly his responsibilities in the sick chamber. What followed was gradual but convinced disillusion. Wholly against the current of his time he grew more and more sceptical of astrology as any true reading of the meaning either of the heavens or of disease.

Nostradamus, the notorious astrologer, visited the Court. He was entrusted with horoscopes for the royal children. Fernel held aloof, and, it is said, kept the king aloof. It was the queen who rewarded Nostradamus—the Queen, Catherine de Medici. The horoscopes of her family had been drawn at Florence by Marsilio Ficino, the Platonist.

Fernel averted his face from astrology more and more. Ten

* *Dialog.* ii, 18.

† Two semi-astrological works of his were: *Monalosphaerium sive astrolabii genus.* J. Fernel, Paris, 2°. Simon de Colines, 1526. *De proportionibus libri ii.* J. Fernel, Paris, 2°. Simon de Colines, 1528.

years before his death he wrote: * "By all means study the heavens for help to man below. The ancients did so as part of their enquiry into the nature of things. And that is right. Even as many do so today. But the astrologer is often an indifferent astronomer. There are among them some who pretend to read things in the stars which are not there. That is an abuse of good faith. They soil astronomy with superstition. Some of them would bind the very freedom of the mind and of our action to the fatality of the stars. There are too, some who disgrace science by deliberate fraud. Illness does sometimes surely derive from praeternatural causes. But are the planets among those causes? Rather the influences of the planets are natural forces, like the sun's light." It comes to this: † "Once within nature and whether the unknown come from the planets or from the elements or from animal or plant, metal or stone, it cannot help or harm except by virtue of just some natural property. The natural cannot cause the supernatural."

Fernel's defection from astrology seemed to many of his contemporaries a strange and lamentable backsliding for a man of liberal view and learned culture. His distrust seemed a reaction against perhaps the most wonderful chapter in the whole of science. We know it now as a chastening of knowledge in the interest of truth. Fernel condemned overtly the astrologers who practised fraud, but, unlike Pico della Mirandola, he published no lengthy diatribe against them. When he had tested astrology and found it to be untrue, he eschewed it as a guide. If it were not true it could not contribute to his system of Nature. His system of Nature had to coalesce with his religion. If astrology were not true it could not be consistent with his Christian convictions. It and his religion could then not harmonize. Fernel could not suffer two versions of the world.

Brief and restricted though this glance at our sample figure of his time, at his beliefs and at his attitude toward Nature, it may at least have served if it makes clear one difference, in regard to natural philosophy, between the human situation then and now. We see Fernel, a product of his time's learning, its humanism, and its religious outlook and no less of its practical

* *Dialog.* ii, 18.

† *Dialog.* ii, 16, at end.

enthusiasm. We find this virile character, in whom knowledge of Nature was part of his special accomplishment as well as of his professional distinction, surrounded by, indeed immersed in, a world which was plagued with magic, astrology, elixir-brewing, the philosopher's stone, and cabbala. A world of superstitions masquerading as knowledge and science, the more dangerously because often sincerely.

He would have needed to be superhuman to free his whole view of Nature, and of natural fact and of Nature as divine symbol, from all the praeternatural with which centuries of tradition, classical, Christian and oriental, had overlaid it. Each item of the natural scene had long been overlaid with superstition, learned superstition and folk superstition. There was as yet no reference-frame of natural law, of chemistry or physics, by help of which to orientate the natural fact. In Nature anything might happen at any time. One explanation, facile or far-fetched as it might be, was almost as good an explanation as was any other. Controversy was indeed sometimes violent over the explanations offered, but the violence was often inversely as their value. As to Nature there was little or no reliable standard for the rightness of a hypothesis. The world-order pictured was one where the doings of Nature were disturbed constantly by the anomalous, owing to intrusion of the supernatural. A bird on the wing from the wood might be what it seemed or it might not. It might be a demonic agent bent on mischief, or it might be an angelic messenger dispensing mercy, or it might be some soul of a departed, harmless though not at rest. It might be a portent or it might not. For the truth of each hypothesis there was no real standard. Indeed, when rational criticism once began to refuse the accepted account of things it could go on until practically nothing was left. One acid test there was, observational fact. But there the accumulated body was as yet small.

Fernel dismissed cabbala as empty and untrustworthy. We saw him, mathematician and student of the stars, early attracted by astrology. We saw him as years went, and his experience ripened as a physician, revise that belief. He tested the claims of astrology in medicine by the crucial test of whether it spoke truth of the sick room. Judged by that test he found it false.

The astrological import of the heavens withered at contact with practical fact. The astral fluid, the climacteric years, the grouping of the planets into baleful and benign, their hegemony of the hours of the day, dependence on them for foreknowledge of the crises of illness, the reign of the houses of the zodiac over human life, to all these his rationalism under the ripening of experience rose gradually superior. How noteworthy an emancipation it was is gauged by comparison with some of the still superstition-ridden even 200 years later.

The victory was difficult, nor did he win it in all directions. Into his prescriptions, always matters of great care with him, we do not go far before finding them leaning for their efficacy upon natural magic. The peony for epilepsy must be gathered in the wane of the moon. Akin to magic is perhaps his ingrained belief that among the herbs of a region are antidotes which, could man but find them, would cure every disease incident in that region.

Fernel struggling over this quicksand had one rock of foothold. It was largely of his own finding, for his teachers and colleagues recognized it little: it was first-hand observation of 'fact'. He impressed that on his pupils. Guy Patin, of his old faculty, praising him in the following century wrote:* "He was a great man. Our fingers have eyes he told us and further have the virtue that they see only what their eyes vouchsafe. Myself, in Christianity I believe as I should a number of things I cannot sense; that is I believe by Faith. But in medicine I believe only what I see." The words apply to the spirit which was moving in Fernel with regard to Nature. Astrology was, if not explicitly yet in fact, part of the Natural Religion of his time. Fernel expelled it from his Natural Religion. He did so by appeal to truth. There was in him a scientific instinct, exceptional at that time, which had, so to say, a new use for truth. "Socrates is our friend, and Plato is our friend; but the truth is even more our friend", wrote old Gui de Chauliac in the *Chapitre Singulier*;† and Fernel doubtless had read him and endorsed his words.

A number of minds were beginning, in the several natural

* *Lettres choisies de feu Mr Guy Patin*; tom. 1; Paris, 1692.

† *Inventarium; Guido de Cauliaco*, Venice, 1480, N. Girardengus; in Italian. [Brit. Museum, B 20783.]

fields they studied, to be not content with facile analogy. In the alchemical procedure with the 'philosopher's stone', which Fernel mentions only to dismiss, correspondence was traced between seven stages of white to red heat in the transmutation and seven successive aeons of the Universe! Fernel may have felt it was time to call halt to such metaphor as argument and to seek in Nature for deeper likenesses than such. Dr Charles Myers tells us that* "no reputable psychologist can be found today who believes that mental processes as we know them occur outside the living organism".

It would seem that in the change from then to now there was perhaps as much to be discarded as to be added. "When half-gods go the Gods arrive." The extent to which, in four short centuries since Fernel, the half-gods in this field are fled would, we may think, now fill him with surprise. Fled and gone and, in the case of these gods, without upheaval of nations, or blood-stained revolution, or successions of martyrdoms. They were part of a view of Nature. The cynic smiles at the suggestion that any view of mere Nature could of itself make a nation's heart beat faster, or impel a people into action. He is right. This transition drove no juggernaut car. It was accomplished quietly by a few, though in time it reached the many. I would feel that it is for us to remember that among those few were some who in great part were searching single-mindedly in the natural for the supernatural they expected there. With honest eyes they gradually established that it was not there, and they said so. Jean Fernel was of these. Their effort and honesty in that morass of perplexity at last lifted the feet of all of us out of it. In this sense the earnest astrologer and alchemist broke ground, or even paved the way, for a Newton and a Lavoisier to come after.

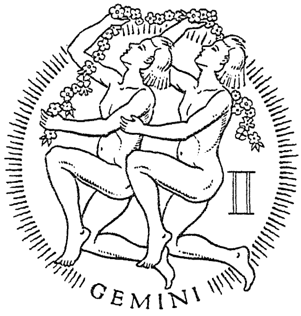
This expulsion of the pseudo-praeternatural from the world was a step toward making the freed world homogeneous. The world as mixture of praeternatural and natural could not be homogeneous. The praeternatural gone, our world became more intelligible and, if you will, less strange. Though truly even as purely natural it contains for us still strange surprises. It is, for instance, a world where we are hurled along at the rate of 1100 miles a minute without feeling the movement. A

* *In the Realm of Mind*, p. 120.

world where little globules around us grow to men and women, without occasioning us surprise, I suppose because we never think about it. Our world is indeed a world extravagantly strange. Yet never for a moment is it a magic world, a self-contradictory world. On the contrary it is tediously law-abiding and monotonously self-consistent. Dullness to boredom, it might be thought. Its facts, however opposed some of them may seem, have a perennial habit of ultimately agreeing. Its facts are for ever reconcilable. Its facts are reconcilable to the degree that if not reconcilable we suspect them of not being facts. Quite unlike therefore are they to our human fancies and ideals, often for ever irreconcilable. What can this reconcilability of natural facts connote? Obviously, for one thing, that all Nature is a harmony. Nature as we saw includes man. Then man is of the harmony. And each of us includes a 'self'. If the fundamental substance of ourselves and of the universe is one, then, clearly, a harmony between them there must be. That Nature is a harmony and we belong to Nature signifies therefore that we and Nature are all one. True this 'self' of ours seems to each of us a something different from other Nature; yet it obviously belongs to the harmony for it is that part of the harmony whence we feel that the harmony is. We therefore are part along with the rest of Nature of that aforesaid faithfully law-abiding and monotonously self-consistent thing, which from other considerations, we saw the world to be. I would not be taken to mean by 'thing' that which is exclusively matter. Fernel's bivalent 'substance' might eke the statement out.

We, in our time, are therefore differently placed for inference from the natural to the divine than were our ancestors some short dozen generations back. They were in much the same social atmosphere as are we. Their ethics were of the same code as ours. The Constitution and the Laws though modified are the same edifice as then. But, our insight into nature is, we can say without exaggeration, of a different order from theirs of yesterday. The sensible world's horizon has not merely receded. The world's horizon is new to the degree of offering a wholly new perspective. The eyes which look at it are new. The old Walpurgis night is over; its company is disbanded; its votaries are fled, its dance will never be resumed; its festival has lapsed, because deserted. The half-gods are not only vanished, they are by nigh forgotten; matter for labels and a museum-shelf.

Yet not for us to forget is our escape from a long nightmare—the exchange of a monstrous world for one relatively sane. To see, and where we can to disentangle, the facts of Nature free from those perplexing mysteries which were in truth not there. There remains and to spare of deeper mystery. The mystery of Nature needs no superstition. Leonardo's Note-books, portraying Nature without superstition, are yet pervaded by its mystery. Today man can go out into the natural world without carrying the distortion of monstrosity with him. We can interrogate the natural world with a confidence drawn from riddance of misunderstanding no less than from extension of understanding. We can see with whom it is we talk. What wears a divine livery can without fear or favour display it to man's gaze. The position for reading from Nature's lips what she may have to say of Godhead never yet in the past was what it is for us today.



III

LIFE IN LITTLE

Recuerdo que una vez me pasé sobre el microscopio veinté horas seguidas, avizorando los gestos de un leucocito moroso, en sus laboriosos forcejecos para evadirse de un capilar sanguineo.

SANTIAGO RAMON-Y-CAJAL, *Recuerdos de mi Vida*, ed. 3, ii, 171.

(I remember that once I spent twenty hours continuously at the microscope watching the movements of a sluggish leucocyte in its laborious efforts to escape from a blood capillary.

Trans. by E. HOME CRAIGIE, Toronto, 1937.)

the imagination represented by the words "accidental play of molecules and atoms" (K. SAPPER, Philosophie des Organischen, 1928) *corresponds to nothing in Nature.*

KEITH W. MONSARRAT, *Human Understanding and its World*, p. 278.

III

We were looking at the mid-sixteenth century. It was a time we can regard as in ways not a few the opening of our own. We were enquiring what the student of Nature then interpreted Life to be. One thing we noted was that he, facing Nature, regarded man, in fine, himself and ourselves, as Nature's chief object and her special care. In his view Nature centred upon man. Said briefly, and therefore inadequately, for Aristotle man was the social animal, for Fernel, physician of the sixteenth century, man was the animal with the immortal soul.

All mankind in one or other of different ways studies Nature. Every man does so perforce in order to live. But down the ages in the civilized community there has been one class of observer of Nature who has given himself to its study more intimately than have the rest. That is the physician. Every allowance made for the variety of human temperament the upshot has been a view of Nature which arrives at being generic and can be called the physician's view. Broadly taken there has been one item of Nature which has held his interest more than any other; the body of man. It is study and preoccupation with the human body which largely determines the physician's view of Nature. Of all the works of Nature, said Galen, physician to the Stoic emperor, it is the human body which bears supreme testimony to the greatness of the heavenly power. Fifteen centuries later we find that sturdy old Pictavian and physician, Lussauld, of the court of the Grand Monarque, outraged by Descartes' thesis "that God formed the human body, the living frame of one of ourselves, out of no other than matter and without putting into it a soul, and in its heart just lit a low flameless fire like that which heats hay or makes new wine bubble".* Where does Fernel stand in this succession?

* *Apologie pour les Médecins, contre ceux qui les accusent de déférer trop à la Nature et de n'avoir point de Religion*, par le Sieur Lussauld, Conseiller et Médecin ordinaire du Roy, 12°, ii, 53. Paris. Damien Foucault, 1663. Contemporary references to the book are made in Guy Patin's *Lettres*, e.g. Lettre 816. The *Apologie* was reprinted, with extensive annotations, by P. J. Amoreux, in 1816 at Montpellier and Paris.

Life was for Fernel a principle which was resident in the body. That principle was not all of a piece with the body. What the body did was the result of its activation by this principle inside it, its 'life'. This settled, certain other things flowed thence. Consequences without indeed observational proof. Considerations, however, derived from arguments of such force and so consistent with the revelations of religion as to be acceptable, although beyond actual observation. Of these were that the human principle of life entered the body at its due time from without, all in a moment, and that at that moment the individual became a separate existence from the maternal existence. This principle, or soul, came to the body from the stars or perhaps from the 'primum mobile' beyond the stars. Further, that at death this living principle, or at least a part of it, that part identified with rational mind, returned from the body to the celestial region whence it came.

This, judging by our type of his time, Jean Fernel, was an interpretation of man as creature which found some general acceptance among those who gave thought to such questions fifteen generations back. Fifteen generations seems, as history goes, a short series to look back across. Yet it may suffice to show how change is trending; seen across it Fernel's picture already bore its streaks of sunset and approaching end.

To ask the definition of life is to ask a something on which proverbially no satisfactory agreement obtains. Bichat described life as a result of forces counteracting death. That was no cynicism on his part; for our purpose, however, it is better perhaps to take some particular form of life as an example of life, and try in brief to describe it and see what it amounts to.

There is a little aggregate of atoms and molecules such as the world we call lifeless nowhere contains. It is confined to living things; many of these it enters into as a unit, and builds up. It is a unit with individuality. Taken singly it behaves as an entire life. In many cases it does constitute of itself an entire life, although but a pin's point in size. Even where the individual is massive it consists, for the longer part of its duration, of many of these tiny units massed together. But its life story still begins with just a single one of them.

The microscope, when in the seventeenth century it came, had this unit so to say waiting for discovery. Our physician-philosopher, Fernel, had written not a century earlier that divide and subdivide a bit of gland or skin or muscle or other part of the body as far as you will, it still remains gland, skin, or muscle, etc. In short, minute muscle was traceable simply back into minuter muscle. The microscope would have undeceived him about this. It would have shown him how, at a little beyond the limit of unaided eyesight, gland and muscle and indeed all parts of the body resolved themselves into little units of structure which, though characteristic for each, were all of them fundamentally of the same type. To these units Robert Hooke of the Royal Society, an early observer with the microscope, gave the name 'cells'. Practically the whole of all that part of the animate world which is individually visible to the unaided eye is built up of cells.

Just as Fernel, through no fault of his own, by no amount of looking could reach the cellular analysis of living things, so too he had no chemical analysis to turn to. Chemistry as we know it was not as yet. There were no chemical elements. Fernel's elements were the four of classical antiquity: earth, air, fire and water. As he said regretfully, these are not to be recognized in the body by observation. They are known only by 'excogitation'.

The microscope had in store yet another surprise about living Nature. A class of animate being had remained till then unknown, because it individually was too small for the unaided sight. The microscope revealed a world of living things so small that without the microscope man cannot see them. It was an astonishment to the early observers that the living principle could be immanent within individuals so small, specks unseeable by the naked eye. Our naïve imagination, it appears, had never entertained the possibility. Buffon, the naturalist, and others were for a time and in a manner scandalized by the news. Man's sense of proportion was outraged. It seemed an indignity to the human form. That a drop of water should contain thousands of individual lives raised a feeling that such a circumstance was derogatory to life itself, and to man. But the fact established itself. These microscopic forms swam, darted, fed, were shaped incredibly, and each was a concrete individual life. In the seventeenth century they came as a revelation comparable with the expansion of the nine Ptolemaic spheres to the immensities of the Galileo-Newton universe. The conception of creation was enlarged in both directions. In one a universe of unimagined vastness, and in the other a fairyland of created beings tiny and various beyond imagination in a single drop of fluid. It was recognized that 'life' could exist as a speck. The cell exemplified that. Reviewing the pioneer work of the microscope in the seventeenth century Charles Singer truly says, "Variety and complexity now begin to overawe the naturalist".* And lately we have come to know that there are individual lives even more minute than the most powerful microscope shall show us. So the revelation of tenuity continues. But these latter are not 'cells'.

Today the contemplation of animate Nature is more 'historical' of view than in those times. Geology has made it so; evolution has made it so; astronomy itself has contributed to make it so. A thought which arises with regard to the cell today is that in the history of the planet at some time, after life had made its appearance under the stratosphere, there must have supervened a period when that organized microscopic structure, which proved the seed of so much significant life and is the cell, arose from still simpler life. It is far too complex to have arisen full-fledged as such. Further, the doings of this little individual life must somewhere and at some time have acquired the property of providing for its progeny to cohere in co-operative organization. Lesser lives thus have co-operated to make larger lives. Man is one of the latest of these latter.

Each of us still at the outset of his or her individual life story is microscopic and one sole cell. By that cell's multiplication, and by its descendants' coherence, each of us attains his or her final form and size. Each at every stage of that astonishing 'becoming' is never any less than a self-centred individual. This is a breakaway from Fernel's view. For him the unborn infant was a mere part of the parent until the soul entered on the fortieth day. For present knowledge the offspring has from outset its individuality. It is never at any time truly a part of the mother. The mother's body prepares a nest for it. Each month the mother's body prepares such a nest against eventuality.

* *Short History of Biology*, p. 171.

The young creature, separate individuality as it is, finds the newly prepared nest ready for it, and occupies it. Ensconced there it thrusts thence suckers into the maternal tissue, and draws from the circulation of the mother nutriment, and in effect breathes through its mother's circulation. The embryo is, however, never any part of the mother, never at any time at all a part of the maternal life, as pious doctrine had supposed. The embryo's life and the mother's life at no time are confluent or commingled. The new life is on its own though it lives as a parasite on the old, a benign parasite, doing the mother no harm and destined at term to set the hostess free. Then the old nest is shed with it, having served its purpose.

The embryo even when its cells are but two or three is a self-centred co-operative society which is familial and a unity—an organized family of cells, with corporate individuality. This character of being an individual seems, as we look upon Nature, a feature peculiarly stressed in what is living. Physics perforce has dealt mostly with 'crowds', but biology has before it commonly the individual. When Aristotle, in living Nature, had reached the *infima species*, he had not reached, as so long was thought, a scientific end-point; rather he had reached a starting-point whence a new scientific problem opened and could be entered on. Aristotle never forgot the capital importance of the individual. Not that Science today clings to any notion that there can be an 'end-problem' in the sense of a reaching of finality. The scientific journey has no end. It has only halting places—points at which the traveller can look round and survey. An end-problem exists only in the sense of a previous problem which carries up to the starting-point of another. Thus, on the discovery of Evolution immediately there rose a next question: "What is variation?"

The human individual is an organized single family of cells, a family so integrated as to have not merely corporate unity but a unique corporate personality. The doings of this cell-assembly are—itself supposes, society allows, and the Law decrees—those of a being which is one, a unity. Yet each of its constituent cells is a life centred in itself, managing itself, feeding and breathing for itself, separately born and destined separately to die. Further, it is a life helped by and in its turn helping the whole assembly, which latter is the corporate individual; such co-operation is one key to what we may call the incorporation, or the integration, of the individual.

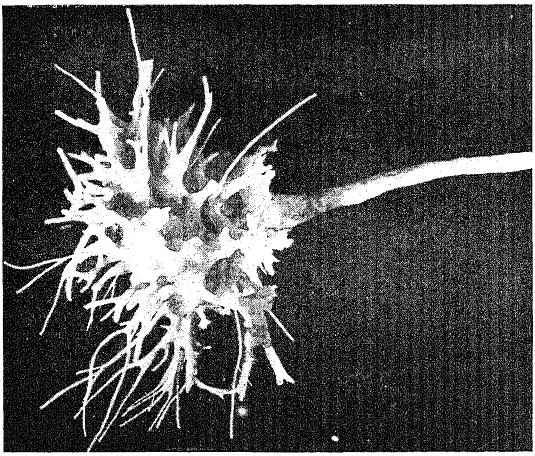
To declare that, of the component cells which go to make us up, each one is an individual self-centred life, is no mere phrase. It is not a mere convenience for descriptive purposes. The cell as a component of the body is not only a visibly demarcated unit but a unit-life centred on itself. It leads its own life. All those doings which our customary scientific rules ask a living thing to do, it does. In the life of the organism of which it is a part it is a unit-life dynamically and structurally. Its shape and visible parts, commonly called structure, are indeed in fact as dynamic as any of its other features. To appearance more stable, as boundary membranes, etc., they are none the less steady states or moving equilibria and as 'living' as the rest. The cell is a polyphasic system whose total average dynamic equilibrium rests on energy-exchange between its parts and between them and its surround, an energy-exchange organized so as to centre on itself. Cells in some cases are joined to each other and might seem therefore not to be separate lives. The microscope may not be able to trace the separation between them. That is so with many nervous cells. They were long thought to be a continuum and not separate. But experiment can discover at once that although they meet there is no union of one with another. Injury or disease separating the cell-component of the junction from the rest of its cell disintegrates that component of the junction and shows, as by a cut with a knife, the point where the two separate cells met, and that they met there without a trace of union.

Each cell is an organized life-system centred upon itself. We cannot say more *qua* energy-system of the sum-total individual of any of us. And in chemical nature also the cell is the same as in chemical nature we are, for there is nothing in us except cells. The cell is a unit-life, and our life which in its turn is a unitary life consists utterly of the cell-lives.

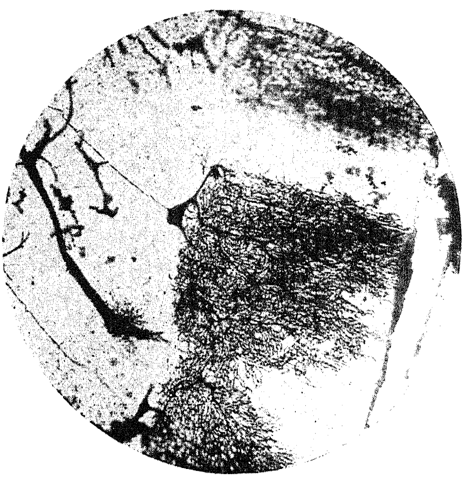
To say that each cell is a unit-life is to say that each cell also is a whole. The cell is not a polyphasic chemico-physical system merely. Many a mere drop of complex jelly could be that. The cell is a polyphasic chemico-physical system which is integratively organized. Hence there comes about that it can answer to what is described as 'life'.

In this balanced exchange with the surround, an exchange which centres on the autonomy of the cell's life, there is essential a certain plasticity which is native to every cell. Adjustment to the nature of the surround is a condition of its life. Where as in the many-celled individual the cell's surround consists of other cells, each cell's autonomy is influenced by the cells in its proximity. That the cell is thus influenced by other cells and co-ordinated with and modified by them must not be mistaken for its no longer having a self-centred life. Its very specialization which results is a sign of its autonomy. To suppose it has become merely a part of some other life than its own is to forget facts. The component cells of the body assert the fact of their individual autonomy of living in many ways. They remain unit-lives. Take for instance the highly specialized static-looking nerve-fibre. It is 'cellularly' (Pl. IV) a slender branch from a nerve-cell 'miles away'. Let it be severed, and the reaction declares at once that a cell's autonomy has been injured. The fibre severed from its cell dies, and the nerve-cell miles away, whose fibre it was, thrusts forth a new fibre to replace the old. Again, at a seat of inflammation the tissue-cells unfix themselves, move about, and resettle down in new shapes as part of the repair. Or, again, when that disaster cancer happens. The cancer-cells which themselves derive from cells of the breast, liver or what not, become active and independent to the degree of resembling parasitic invaders of the body. Watched in a motion-film, where life's movements are speeded up perhaps a 100 times, they seem almost audible as they jostle past and push through the 'quieter' normal cells. They seem possessed by a kind of senseless frenzy, senseless because, although imbued with prodigious and reproductive energy, like that of the cells of an embryo, they and what they build are planless. In the healthy body everything is planful. The many-celled organism such as each of us is, was one cell at beginning, and when it has become many-celled the behaviour of the constituent cells shows that each one of them like the parent-cell is still an autonomous unit-life. But the behaviour of the individual cell in the body is restrained by influences of its

Photograph of living blood, showing its cells; magnified about 900. The numerous disc-shaped cells are those containing the respiratory pigment. They are not actively motile, but are carried by the blood-stream. The single larger cell devoid of pigment moves actively, can attack invading germs, and from its likeness to a pond-amoeba is called amoeboid. The clearer central area in it is the nucleus.



Model, greatly magnified, of a large nerve-cell from the brain of a fish. Its bristling brush-like part is 'receptive' for messages from a distance; its single stem-like projection to the right is its nerve-fibre transmitting the messages to a muscle-like organ at a distance.



A nerve cell in the dead brain, stained with silver. It carries a tree-like branched 'input' end for receiving 'signals', and (to the left) a single thread-like 'output' for transmitting 'signals' to nerve-cells at a distance. Greatly magnified.

PLATE IV

fellow-cells. The desistance from further growth beyond the adult stage is partly traceable to this. There is a scrap of tissue from an embryo-chick transferred to artificial culture 27 years ago which is growing vigorously as ever now today; if left within its chick it would have ceased years since.

Some of our cells, although they are part and parcel of us, have not even fixed coherence with our 'rest'. Such cells are called 'free'. The original cell which started the whole body was free, as are all those of that particular kind. And others too are free. The cells of our blood are as free as fish in a stream. They are in the stream of the blood. Some of them resemble in structure and ways so closely the little free-swimming amoeba of the pond as to be called amoeboid. The pond amoeba crawls about, catches and digests particles picked up in the pond. So the amoeboid cells inhabiting my blood and lymph crawl about over and through the membranes limiting the fluid channels in the body. They catch and digest particles. Should I get a wound they contribute to its healing. They give it a chance to mend, by eating and digesting bacteria which poison it, and by feeding on the dead cells which the wound-injury has killed. They are themselves unit-lives, and yet in respect to my life as a whole they are components in that corporate life.

The human situation today as regards the conception of life is therefore not where it stood with our sixteenth-century philosopher-physician. Simple visual magnification with enlarging lenses brought about a change which would have startled Jean Fernel. His life principle, which in virtue of its simplicity as a unitary whole was imperishable,* is faced with having to resolve itself into millions of local principles, operating each of them one tiny speck of material. There is a little book written in Henry VIII's time by one who was at once a physician and a divine, Dr Peter D'Acquetus, a chaplain to the Bishop of Ely. In it are set down a number of questions about which he is curious and has consulted learned friends. One of these questions is whether the hairs of the head grow after death. Meaning by death the flight of the soul from the body he has no answer to what seems to him incredible. Nor would he have understood if he had been told the hair still goes on living for some

* *De Nat. Parte Med.* v, 18.

time after heart and breath have ceased. Perhaps some physician of his time would have answered him that Aristotle regarded the *anima* as in not a few instances divisible, and that it might linger longer in some parts than in others. But he might well have thought that savoured too much of Averrhoes, the infidel commentator, to insert it in his book. Fernel's faculties of the psyche have multiplied so as to be numberless. To this he might probably be led to say, "the immanent spark of life pervades every speck of material of the body". What would have given him pause would have been this divisibility of the indivisible psyche.

The biological problem of life fell asunder in so far into two subdivisions, the life of the constituent cell and the life of the total constituted organism. The former subdivision oddly is called general physiology, the latter special physiology. A significant gloss upon that is that the total organism begins as one cell. That does not mean that the problem is in the beginning a general one and becomes special. It is special from the very start, as well as general; and it remains general to the very end as well as special. The human starting-point even at outset, when but one single fertilized cell, is already not general but 'human'. It is as human at the beginning as at any later time, even if there comes later, in the concrete case, the wearing a stove-pipe hat.

The life of a cell, what conception may we form of it? A speck of material which is said to 'live', while the vast majority of specks of material are said to be lifeless. Has it some particular element of matter in it which those other specks have not? No; that is not the key. The elements of matter—and we are thinking of them now not in Fernel's sense but in that stricter one of the chemical 'element' of today—in the living cell are among the very commonest of those spread broadcast in material which does not 'live', in soil, rock, air and water. Perhaps what strikes us most in the list of chemical elements which make us up, is the negative fact that the majority of elements are left out, and all the rarer ones. But in the speck that lives the common elements are differently compounded. For one thing they compose a tiny droplet of granular jelly. That is, it is not material in any one single pure phase, solid, fluid, or gaseous; it is a mixture of all these. That is partly phrased by calling it colloid.

A good many years ago with the recognition that this jelly was the 'physical basis of life' it was christened 'protoplasm'. The name is less heard now than formerly. It serves to recall that the living material of the cell was then thought of as one definite specific compound. It might perhaps better have been called *X* as an unknown quantity. But that would have been less attractive and less intriguing. The name stood for a something, a compound substance, which as a chemical entity was a scene of living behaviour. It was thought of as broadly presenting two types of action, one a building up and one a breaking down. To call it protoplasm helped to substantialize it. As to its chemistry and what that precisely was, those were points left to a future admittedly far off. To attack it by chemical methods had, at that time, to face the paradox that such methods at once 'killed' it. The protoplasm was then no longer protoplasm, because by definition protoplasm was alive. To attempt the chemistry of life at its seat seemed therefore like asking to handle the rainbow's end. It was an entity but a will-o'-the-wisp. The spell of Galen was in fact over life still, in act though not in name.

To this phase there came a change. Before many years the organic chemist and the physical chemist entered biology. Their experience hitherto had been with crystalline stuffs. Perhaps they had not so often as had the rank-and-file biologist lingered over the microscope and followed, as had he, the mysterious dance of the nuclear segments about the astered spindle in the living cell. Perhaps they would not have cared if they had. However that may be, attacking life they did not hesitate to grind into unrecognizable fragments the living cell for obtaining from it what might be inside it. To many biologists this seemed a Philistine procedure. But it was an audacity which reaped a great harvest of new knowledge. Their mush of unrecognizably disintegrated cells, obtained by freezings, mincings, crushings, grindings, squeezings, yielded to chemical analysis secret after secret of cell-life. Protoplasm, or *X* (which of either we please to call it), became as entity a thing of the past. The cell was tenanted not by one thing but by many things, whole systems of things. It amounted to a little world of things.

Microscopic it is, but large as compared with some other structures which individually live—for instance, the bacterial spore, and the lately recognized 'virus' smaller still. It is, of course, vastly larger than is any molecule. It is often itself a manufacturer of some of the very largest molecules, but when so they all comfortably house within it. There would be room on the surface of one cell for some hundreds of millions of the great rod-shaped or skein-shaped protein molecules, bristling with chemical receivers. Again, compared with those units, whether particles or waves, into which modern physics resolves matter, the little cell is a stupendous aggregate. Its content of these rushing whirling electrical charges, some of them spinning many millions of times a second, is beyond practical enumeration. We remember the pains our sixteenth-century physician was at to show that the principle of life is simple, an indivisible unity. Having no parts, being structureless, and therefore unable to come to pieces, it was immortal. From that the conception we are approaching seems to retreat farther and farther.

Essential for any conception of the cell is that it is no static system. It is a material system and that today is to say an energy-system. Our conceptions of it fail if not dynamic. It is a scene of energy-cycles, suites of oxidation and reduction, concatenated ferment-actions. It is like a magic hive the walls of whose chambered spongework are shifting veils of ordered molecules, and rend and renew as operations rise and cease. A world of surfaces and streams. We seem to watch battalions of specific catalysts, like Maxwell's 'demons', lined up, each waiting, stop-watch in hand, for its moment to play the part assigned to it, a step in one or other great thousand-linked chain process. Yet each and every step is understandable chemistry. The cell has proved to be a perfect swarm of catalysts, or of trains of catalysts, each a link in a serial suite of chemical action.

An aspect of the cell which helps towards understanding it, both as chemistry and as life, is that although it is fluid and watery, most of it is not what is called a true solution. Judged by present-day lights a drop of true solution, of homogeneous liquid, could not in our ordinary sense of the word 'live'. It is too remote from 'organization'. In the cell there are heterogeneous solutions. The great molecules of protein and aggregated particles are suspended not dissolved. A surface is a field for chemical and physical action. The interior of a pure solution has not in that sense surfaces. But the aggregate of surface in these foamy colloids which are in the cell mounts up to something large. The 'internal surface' of the cell is enormous. It offers a vast field for chemical action. The cell gives chemical results which in the chemist's laboratory are to be obtained only by temperatures and pressures far in excess of those the living body has at its command. Yet in the cell these results are obtained without those temperatures and pressures. Part of the secret of life is the immense internal surface of the cell.

In the spongework of the cell foci coexist for different operations, so that a hundred, or a thousand different processes go forward at the same time within its confines. The foci wax and wane as they are wanted. That the cell's field is a colloidal field makes explicable much which would otherwise not be so. But the cell is much more than merely a droplet of colloidal jelly. The processes going forward in it are co-operatively harmonized. The total system is organized. The various catalysts work as co-ordinately as though each had its own compartment in the honeycomb and its own turn and time. In this great company, along with the stop-watches run dials telling how confrères and their substrates are getting on, so that at zero time each takes its turn. Let that catastrophe befall which is death, and these catalysts become a disorderly mob and pull the very fabric of the cell to pieces. Whereas in life as well as pulling down they build, and build to a plan.

These and many considerations force on us the conception of the cell as 'organization'. One of its aspects must be definite spatial arrangement. There is in every cell a visible kernel called the nucleus. It is directive; a central nest of ferments. Remove it from the cell and the cell's rest gets out of gear and dies. There is too the cell's outer surface. It would seem the proteins there connect with those of the nucleus by protein threads. Proteins, which are the very basis of the cell, provide it with a sort of quasi-skeleton. They can make semi-rigid rods; they can spread film-like, in touch with the fatty films of the cell's outward skin. The cell thus gets a subvisible skeleton in accord with the scheme of its internal directive organization. The cell is of course in constant commerce with the chemical world around it. In the case of a cell inside the body packed in among the others this chemical world around it is a very special chemical world. We can regard the cell's outward surface as a mosaic of a million chemical poles attracting to it and retaining what can dovetail with their pattern and enter the electrical construction. Its outer surface also leaks like a sieve allowing molecules to be expelled and drained away when done with.

The cell is an organized factory conducting manifold chemical processes. It hydrolyses, it pulls to pieces, it excretes. Further, it constructs. From bacterium to tree, from animalcule to man, proteins, broadly, taken are the stones of which the house of life is built. The cell makes its own proteins. It remakes them for itself from others supplied to it. 'Life' is a maker of proteins.

The red pigment of our blood does exquisite things. The 'flame' of life is scarcely metaphor. Our blood pigment uses the circumstance that iron is a metal which plays fast and loose with oxygen. Iron notoriously easily oxidizes and de-oxidizes. Our red pigment owes its colour to iron. It picks up oxygen from the air at the bottom of the lungs and travels with it and distributes it to all the several organs of the body. This taking and giving of oxygen by the iron-containing pigment is managed by minute differences of oxygen pressure. A few millimetres more oxygen pressure in the lungs drives the oxygen there into the pigment in the blood; a few millimetres less in the other organs allows the oxygen to be sucked by them from the pigment in the blood. For this to work successfully the tie by which the pigment holds the oxygen must be weak, and the physical constants required of the pigment have to be extremely true to standard. The required precision is meticulously met. In different animal species the physical constants differ just enough to fit in each species that species' peculiar needs. Thus this pigment makes its specific contribution to life. It is a superlative oxygen-carrier for the purpose. It is not too much to say that it has rendered possible the type of life which is ours, and much other life as well. Each of us produces it daily in quantity sufficient to make good an equal quantity decomposed. The manufacturing of it by the animal body seems to have come about perhaps some hundred million years ago. The breed of cells which 'invented' it have never in all that time lost their trick. The evolutionary argument tells us that cell-chemistry has 'invented' it not once but several times. Cells of widely unrelated ancestry are producing it today; their ancestries must have separately invented it. Though these many living cells construct it, its construction lies beyond the skill and means of even the latest chemical science. Very complex, it is a miracle of efficiency for what it does. If it be claimed that animal and man are marvellously designed to meet the circumstances of Nature and that this pigment and its 'invention' bear tribute to the purpose and knowledge of that Design, this might seem indeed to offer a text in illustration. But collateral fact submits a curious gloss on that text.

A familiar chemical process is that which is called combustion. It is one of the chemical processes which man induces and employs on an ever-increasing scale in his demand from Nature for heat and power. It presents two forms; complete combustion where oxygen supply is in excess; incomplete combustion where oxygen is insufficient. Incomplete combustion produces carbon monoxide gas. Our blood-pigment reacting so beneficently with oxygen reacts also with carbon monoxide. Its chemical tie with carbon monoxide is stronger than with oxygen itself. If in the air we breathe there is carbon monoxide as well as oxygen our blood-pigment takes the monoxide. But whereas our body, for instance our brain, cannot live five minutes without taking oxygen, carbon monoxide is no use to it. If our blood brings us carbon monoxide instead of oxygen we die of asphyxia, 'suffocation'. "Carbon monoxide is the cause of more deaths than those due to all the other gases. As an industrial poison it is second only to the worst"; so writes Dr Yandell Henderson, a leading authority on the matter. By reason of the chemical affinity between it and our blood-pigment, carbon monoxide "becomes a prime enemy of all red-blood creatures. The use of fire was man's first successful step in controlling the forces of Nature to his needs; but it brought with it the hazard of asphyxia", because of our blood-pigment. Claude Bernard first demonstrated this chemical predilection of our blood-pigment for carbon monoxide. It is today a gas which not only every hearth but every motor-car exhales. Our blood-pigment can be a fatal danger to us.

Part of the story of the development of life from our planet's side is its key-use of oxygen. And in due course in that story came the construction of this subtle pigment which decisively increases life's access to the planet's oxygen. With it life opened a new vista of possibilities to itself. How it achieved its new instrument has not been traced. It is, we saw, a chemical means. If we project our human self into the problem of devising it, how should we proceed? Our purpose we should have and, such as they are, our knowledge and our reason. As to our device to meet what was required, reason would enquire into how the pigment acted. Reason would thus find the device deadly under certain allied situations. Would reason then resort to the device? Was then Nature's method mere trial and error, hitting off an *ad hoc* means which met part of the situation and introduced new dangers of its own? Our Fernel might interject, "the choice may have been this device or nothing". If so, we are back at Lucretius: matter is stronger than Olympus.

We are wont to figure the cell predominantly as structure. But our conception of it will be then even more inadequate than it need be, if we forget for a moment that it is a moving structure, a dynamic equilibrium. It is a moving system so constituted as to establish itself and maintain itself for a time—a time which is very brief as compared with the persistence of many inanimate things. From and to the world around it takes and gives energy. It is an eddy in a stream of energy. It has the power of throwing off from itself other eddies specifically like itself. In that way, though its personal eddy is brief, its specific eddy as a species lasts immensely longer. But that eddy has inherent in it tendencies toward change, so that, where we are able to look back far enough, we find great numbers of its specific forms have vanished, and a multitude of modifications taken their places. These too are all on their way to change. What the change will be in our own case is not without interest for us. But it remains at present largely beyond our forecasting.

If we could forecast it better perhaps we might, to some extent, control it, having a policy in view.

Returning to the definition of life, let us hear a gifted biochemist of today define life from his standpoint. "Biologists find", says Dr Needham, "their work is only possible if they define life as a dynamic equilibrium in a polyphasic system consisting of proteins, fats, carbohydrates, sterols, lipoids, cycloses and water." These terms are somewhat technical. The statement is in fact admirably lucid and comprehensive. It says a physical system made of certain chemical substances exhibits all that biochemistry discovers in life.

It is a delicate system. That is to say, if we regard it as a stream of movement which has to fulfil a particular pattern in order to maintain itself, then it is, relatively to the fields of movement in matter which we do not call living, more liable than many to be irretrievably disarranged and so fail to maintain itself. To be thus irretrievably disarranged is, if physics and chemistry admitted the word, to die.

In brief, it is an energy-system whose energy is turned to maintaining itself; for instance by (1) nutrition, that is replenishing the system with more energy in suitable kind; (2) growth, that is, extending the system; (3) excretion, that is, separating from the system energy no longer suitable in pattern; (4) mass-movements of its parts, an activity which is intrinsically developed, such as locomotion, feeding and so on; (5) reproduction, that is, generating a new system independent of itself, a young individual potentially at least of its own kind. To behave in this way is in common and convenient phrase to manifest life. It involves dependence on its surround for energy. It is a conception unthinkable apart from its surround. It is so locked into its surround that to extract it thence is to break it in all directions. It means a system ceaselessly taking energy from the surround, and shedding energy back thither. But what is shed would not do again as such for replenishing the living system. Life would mean therefore an ultimate exhaustion of the surround in regard to the energy which can support life were it not that life itself, taken in the sum, secures itself against that terrestrial impasse. Not uninteresting to compare with this is Fernel's argument that were matter not imperishable life would by now have used all of it up.* That is a remark on a scale quite unusual in Fernel's time.

There are a great variety of these energy-systems conveniently spoken of as alive. Some of them contain, making it chemically for themselves, an organic compound more complex, and, broadly taken, of even wider import, than the blood-pigment just spoken of. It is a compound which, so to say, traps a certain fraction of the energy reaching our planet from the sun. With this solar energy it constructs chemical compounds whose energy-store is of a kind that living systems of almost every sort can make use of it. Our sixteenth-century physician-philosopher, holding to what tradition had long said and sung, was right in his veneration of the sun's influence, although he could not then know that the sun's light holds the key to the green plant, and the green plant the key to life animal and human.

It might seem that Fernel's insistence on the importance of the sun's ray to life, forecast in some measure what is known today. "Consider", he says, "the excellence of the sun, prime prince and controller of the world, favouring and forwarding every life that is. By its chastened heat it supports all living things in their doing what they do." † The sun's heat he held to be not the same as elemental heat, the cardinal quality. It was a vital, a vivifying heat, in a sense which 'heat', the cardinal element, was not. May we suppose from such a passage that, allowing for its general terms, and accepting it as somewhat figurative, our physician-philosopher, writing in the strain of much which had fallen from older centuries, has a conception of life not greatly different, broadly taken, from ours of today? To suppose so would be to mistake him.

For him a specific principle, life, was within each living thing and made it alive. That principle was a something from the sun. Why the lifeless did not live was because that principle was wanting to it.

Today in both respects our thought is different. Instead of a specific principle which is life, life is an example of the way in which an energy-system in its give and take with the energy-system around it can continue to maintain itself for a period as a self-centred, so to say, self-balanced unity. Perhaps the most

* *Dialog.* i, 1. † Cf. *supra*, p. 25.

striking feature of it is that it acts as though it 'desired' to maintain itself. But we do not say of the spinning of a heavy top which resists being upset that it 'desires' to go on spinning. The very constitution of the living-system may compel it to increase; thus a self-fermenting protein-system, granted its conditions, *must* increase. Broadly taken however there is in 'living' nothing fundamentally other than is going forward in all the various grades of energy-systems which we know, though in some less rapidly and less balancedly than in others. Whether atom, molecule, colloidal complex or what not, whether virus or cell or plant or animal compounded of cells, each is a system of motion in commerce with its surround, and there is dynamic reaction between it and the surround. The behaviour of the living body is an example of this, and we call it 'living'. The behaviour of the atom is an example of this and we do not call it 'living'. The behaviour of those newly discovered so-called 'viruses' is an example of this and there is hesitation whether or not to call it 'living'. There is between them all no essential difference.

The difference is one not of ultimate nature but of scheme and degree of complexity, nothing more. The elemental parts and elemental patterns are not novel. The atoms and sub-atoms are among Earth's commonest. 'Living' becomes a name for certain complexes of them, arrangements of which it may be said that they are organized integratively, i.e. to form a solidarity, an individual. Hence we do not speak of 'life' in association with absolute simplicity of organization; never with mere homogeneity of structure. It requires a heterogeneity which permits integration of its complex even if that latter be but a single cell. Thus, when the skill of Robert Chambers extracts the nucleus of a cell, the cell, bereft of that little organ, 'dies'. When its integrated coherence ceases, as sooner or later it will, it falls asunder into parts which are simpler and do not form a solidarity; and that is called 'death'. Fernel if he agreed to this way of thinking would still add "but you omit the 'cause'; the cause is withdrawal of the 'principle of life'". Yet an energy-system which we call 'alive' does not radically depart from energy-systems which we do not call 'alive'. Both are chemical. Moreover the naturalist can point to a number of systems which fall into series between the 'living' and the 'lifeless', thus the new 'viruses' dubitably better called alive or not alive. Life as a distinction between physico-chemical systems is a convention; convenient but not scientific. The law of the land defines life; it must for social convenience do so; but it does so after the manner of framing rules for a game, as: "the ball is dead when beyond the white line." Chemistry and physics refuse to define life; they eschew the word. How would Fernel have looked at the life of a cell, had the cell as such been known to him? His principle of life in the whole body was we remember single and indivisible; it was although *in* the body not *of* it. He would have seen his global principle fall apart—in man into 15 billions of unit principles, each of which lives. The body's 'life-principle' has become particulate even as the body's matter is particulate, its particles which are said to live being called 'cells'.

Each such cell has its 'faculties' as Fernel had described in his paradigm of the 'life-principle'. Each has its *facultas attractrix*, its *facultas altrix*, its *facultas genetrix*, etc., and the microscope displays its faculties of moving, of ingesting, of excreting and secreting, and it has even that other faculty, new since Fernel's time, the faculty of breathing. Fernel in fact would feel convinced that this speck, the cell, has 'life' in it. For instance a speck-sized sample of them taken from a chick-heart 27 years ago and subcultured is still growing fast as ever!

Nor, accepting, if we do, the concept 'life-principle', does the scale of the particulate life reach its limit at the smallness of a body cell. The bacterial spore, and the 'virus particle' are far smaller than the body cell; they yet display in Fernel's term the 'faculties' of life, assimilation, secretion, growth, reproduction, spontaneous motion, and the rest.

These faculties are however processes which examination resolves wholly into chemistry and physics. Chemistry and physics find them not separable from the rest of chemistry and physics. What we call by convention 'life' is then chemico-physical. Why not, then, say of other energy-systems than that of the 'cell' or of the body *in toto* that they have life? Why not say so of the rock as well as of the tree? Why not of the component molecules of the cell as well as of the cell itself? There is indeed no good ground for speaking of these as living, those as not-living. When Professor Blackett speaks of the mean life of the mesotron particle and the Insurance Office speaks of the mean life of ourselves his particle's behaviour gives him no less right to do so than does ours the Insurance Office. Each is an energy-transaction which at some time ceases to be what it was.

If a definition has to exclude as well as to include, it must lean on a logical boundary of what it defines; the term life has no such boundary from lifeless. Fernel seeing man, his type of the inseparable unity of the 'life-principle', disrupted into billions of microscopic lives may well ask to be shown, not only that these component unit-lives are demonstrable as 'lives', but that this mass-life of the body and its organs is built up from them. He would learn that the study of physiology now commonly proceeds on that assumption and never finds it fail. He would be shown this great organ or that separated from the body and removed to an incubator and perfused with a warm nutrient fluid, and still as an aggregate of cells continuing to pursue its own organic life, and doing so for weeks at a time. The heart continuing to beat; the pancreas to secrete insulin; the thyroid gland to secrete iodine, and to respond, by secreting more iodine, to a thyrotropic hormone added to the perfusion-fluid, as would the human being. The synthesis is thus offered him as well as the analysis. He is faced by his cardinal humour, the blood, instead of being an ebb-and-flow of fire drawn from the stars, being a nutrient fluid perfusing the body at large; and the heart, his regenerating alembic for the supra-stellar fire, being a force pump driving the perfusion-fluid round. The perfusion-fluid itself is chemical nutriment for all the cells of body, supporting their energy-needs. They are indeed the myriad lives into which the one and indivisible global 'principle of life' has by progress of knowledge been disrupted.

The thought might rise unbidden to Fernel, that instead of an occult 'principle of life' superadded *in toto* to the total body, it were simpler to suppose a population of minute systems each doing its bit of living for itself. Further, for these systems, since physics and chemistry are adequate to what each of them does, to omit the occult principle altogether as a superfluity. Then for each the circumlocution that it has life in it becomes unnecessary; it could be simply said of it, it 'lives'. The occult life-principle is thus, after the plan of Occam, dismissed as a 'superfluous cause'. But no, the idea of matter working itself seems to have been foreign to Fernel and his time. Disciple of Aristotle though he was there is nothing to show that he ever took Aristotle's point that matter might work itself.

The word 'life' still remains useful; a convenient, though not exact, term for all that exhibits the 'faculties' regarded as characteristic of 'life'. The total life is seen as an additive result; not simply additive, but additive by co-organization of integrative kind. There, as Fernel insisted, the harmony of the whole is not merely built out of its parts but is impressed on the parts by the whole. An individuality whose whole, as luminously said by Coleridge, is presupposed by all its parts. A conception which has been revived notably by General Smuts as holism; German 'figurism' has recently expatiated on it.

I imagine the nearest to a differential characteristic of the 'living' energy-system is that the living energy-system, in commerce with its surround, tends to increase itself. It is like a train of fire which finds fuel for itself. If we think of it as an eddy in the stream of energy it is an eddy which tends to grow; as part of this growth we have to reckon with its starting, as we said, other individual eddies from its own resembling its own. This propensity it is which furnishes opportunity under the factors of evolution for a continual production of modified patterns of eddy. These patterns evolve some of them an increasing complexity. It is as though they progressed toward something. But philosophy reflects that the motion for the eddy is in all cases drawn from the stream, and the stream is destined, so the second law of thermodynamics says, irrevocably to cease. The head driving it will, in accordance with an ascertained law of dynamics, run down. A state of static equilibrium will then replace the stream. The eddies in it which we call living must then cease. And yet they will have been evolved. Their purpose then was temporary? It would seem so.

The 'motion' of an energy-system is its 'behaviour'. Various types of organization of system produce on that basis various types of behaviour. A grey rock, said Ruskin, is a good sitter.

That is one type of behaviour. A darting dragon-fly is another type of organization and another type of behaviour. We call the one alive, the other not. But both are fundamentally balances of give and take of motion with their surround. To make 'life' a distinction between them is at root to treat them both artificially. Fernel invoked the sun; the solar energy is a circumstance belonging to the energy-surround for both. We may consider the dragon-fly the more delicately balanced system with the more intensive give and take. Directly and indirectly through the collateral system of the green plant, it has the more acute commerce with the energy-system of the sun. We may judge it a more organized and integrated system than the rock, and it is certainly the more fleeting one. But these are details when we view energy-systems generally. Then as pure energy-systems rock and dragon-fly come together within one category.

But if there be no essential difference between 'life' and all the rest, what becomes of the difference between mind and no-mind? There is that to be answered. To answer we may follow this hierarchy of systems and things downward and see at what point mind quits it. Unless we can do that who knows that mind *has* left it? Of ourselves, yes, we know we have a mind. And the dragon-fly? Yes, it may have a mind. And, amoeba? It may have, but how are we to know? Then of the grey rock? Do we know? If the imagined boundary between life and no-life will not stand examination, may it not be that that between mind and no-mind will have to go?

For Fernel rock and dragon-fly were utterly and irreconcilably apart. They were kept apart because 'life', an 'incorporeal' principle, was in one and not in the other. Traditional use of old habitual words tends to conceal their drift apart. Thought on this subject has moved far since Fernel. We see it when we reflect on its repercussions for the physician in the sick room. Today the body's problems present themselves to him as chemistry and physics. Alas, for Fernel, by reason of his time, of physics he had little and of chemistry still less. But, even further from today than that, he studying his patient could not guess that in chemistry and physics lay the direction of his problem.

Life as an energy-system is so woven into the fabric of Earth's surface that to suppose a life isolated from the rest of that terrestrial world even for the shortest space gives an image too distorted to resemble life. All is dovetailed together. The very place of each concrete animate thing is its own place, and any other would misfit it. Here too we differ from Fernel and his century. He could in thought transfer the life, the subject of his study, from our earth's surface to the stars and back. He had fewer criteria than we. And he had in thought a substance, a principle, self-contained and free, indivisible, immortal and otherwise undefined. We remember how vastly the almost inconceivably small and the almost inconceivably great have extended since then. Yet in doing so they have left no gap between their extremes. In the immense jig-saw puzzle there is but one place into which each several piece will fit. Of translocation such as Fernel's pious fancy pictured little possibility is allowed.

Life, as we know it, is always specific—specific in time and place. Surely, it is of where and when it is, and of no other where or when. All of life as we know it could exist probably nowhere else than on this planet's surface, where it is. Even our near neighbour, the moon, offspring, as are we, of our own planet, would be too uncongenial, too cold and waterless and airless; life there would perish. Nor would it tolerate Earth's nearest sister, Venus. Nor could our good neighbour Mars in all neighbourliness give, virtually without oxygen as it is, hospitable asylum to any life vagrant from us. The types of system which here 'live' would not subsist or maintain themselves there. A life on Jupiter would be bathed in clouds of solid particles of methane and ammonia. Mars, however, is said to have a something of its own which exhibits seasonal growth and change.

A great American physiologist, Lawrence Henderson, has set forth* the particularity of the physical and chemical conditions whose concurrence on Earth's side render possible the existence of the systems we call 'living'. Certain anomalous properties of water, in conjunction with unusual powers and space-relations of the carbon-atom, along with exceptional conditions

* *The Fitness of the Environment.*

of radiation and temperature, are shown to form a sort of conspiracy of circumstance allowing life to be, and here and now. There was a stage 'in the dark backward and abysm of Time' when our planet's side was not as yet a place possible for the life now around us. A stage ensued, however, when things would by a bare margin just permit the type of energy-system we speak of as living. Slender though that chance, it was, so to say, seized. Life appeared. Perhaps in some warm runnel of tidal mud or frothy ooze. It would, we must think, be a tiny thing, perhaps clustered and numerous; to all outward appearance impossibly fraught with what it has become today! It was, we may think, perhaps numerous, but in microscopic specks. Yet its destiny was to invade the land and clothe continents with its growth. To venture ocean and in time to populate it. To populate it with countless millions of feeding mouths, and to feed them, while their fins oared them about, fins prophetic of the birds' wing, and of the human hand. Millions of feeding mouths voiceless but yet potential of birds' song and human speech. Mere mechanism and yet charged with germinating reason.

Here the Cleanthes of Hume's Dialogue might tell us that for this the preparation of Earth's surface was. That it was *for* the advent of life. That conspiracy of circumstances which has been pointed out as affording unique opportunity for life to be, was itself, he might tell us, a preparation for the event in store. It was all in expectation and foreknowledge of the peculiar conditions attaching to life, without which life could not be. So the conspiracy went forward. So, he might tell us, with that extension of living forms, which has come to pass, each new form finds within the general structure of the Earth's side some niche ready for it. A benevolent place in the economy of Nature which permits it to thrive, a nest as it were, made ready for it to house and breed in and where its young may be reared.

To this, his antagonist of the Dialogue, a Philo of today if we may venture so far, might perhaps rejoin: "Cleanthes, are you not treating as one thing two which are not similar? You speak of the beginnings of life on the earth, and then of the extension of life's forms which has come about on the earth's surface since life's first advent here. We accept this latter as a fact because the factual study of the earth's history documents it to us. In the serial millions of years which have passed since life appeared new forms of life have arisen, all of them variants of its one broadly taken central pattern. But that diversity can possibly be taken as evidence of an adaptability on the part of this type of energy-system which we call life, enabling it to adjust itself to different conditions within limits and still to persist as a moving equilibrium fulfilling the requirements of its own replenishment and repetition. An eddy in a stream can survive many changes in the form of the channel. That it does so, does not presuppose that an alteration in the channel was made just such as may allow the eddy to persist. In regard to the appearance of new versions of the form of life it seems simpler to suppose that the proved adaptability of the living system allows it readjustments within limits to circumstances of its surrounding. That seems simpler than to predicate for the surround or for the total economy, life and surround together, a prescience of futurity, not to speak of a prescient activity which commands design."

May we suppose Cleanthes to accept such possibility, and Philo to continue, "But the initiation of living systems, that is a different problem. The living system as we see it and as its history, traced to the extent we can trace it, exhibits it to us, has the character of adaptation. That is an observed datum recognizable in its behaviour since it arose. But for the living system to come into existence we have to suppose that it arose from some other form or forms of energy-system. In other words from some system or systems which we should not call alive. How such a system or systems could change so as to behave as living systems behave is a problem less open for us to judge because we do not observe it in process. The existing facts of today give little help. A metamorphosis of non-living matter into living is going on today. But it is not going on in the meaning we had in mind.

"The turning of non-living energy-systems into living ones does go on today, and wholesale. Lifeless energy-systems from the air and soil and the sun's radiation, the plant builds up into the living energy-systems of itself. You remember what old Lucretius very prettily said—though I know you do not agree with him in some ways.

> Praeterea cunctas itidem res vertere sese;
> vertunt se fluvii frondes, & pabula laeta
> in pecudes, vertunt pecudes in corpora nostra
> naturam, & nostro de corpore saepe ferarum
> augescunt vires, et corpora pennipotentum.*

"These transformations of lifeless into living offered no mystery to Lucretius. He trusted his enchanted 'atoms' and they did it. How they did it he leaves unsaid. So we must be content with that, and can follow him no further. Neither was this quickening of dead food into life a puzzle to our good Fernel. He had like Lucretius his fairy-like agents, only with him they were called 'faculties'. Fernel tells me† my breakfast once in my veins and hey-presto with a stroke of the wand—or more precisely with two strokes—life is conferred on it. The first stroke, given by *facultas procreatrix*, prepares the matter to receive 'form', i.e. the principle of life; the second by *facultas altrix* actually confers the 'life'. You may judge it a calling 'of spirits from the vasty deep'. But that is the sole difficulty; that granted the rest follows.

"Cleanthes, the difference between my rose bush and me—aesthetics apart, where I know it has the advantage—is a question largely of how we feed. I, or my friends for me, must quest about for the food I take; but my rose bush quietly feeds on the soil and air it is in. That makes it a restful neighbour, whereas I am a restless, even an aggressive, one. The herd in the meadow are peaceful compared with the fly-swarm which teases them, but the green elms are peacefuller still. These feed and grow statelily enough on the very soil and air with which they stand in contact. But I, more like the herd and fly-swarm, have to quest for, and run after, my food. The lifeless systems I can vivify I have to seek and ransack for. Unless I get them I lapse. At root that it is which gives me nerves and makes of me a restless, even aggressive, fellow. Yet after all there is—aesthetics apart—greater likeness than unlikeness between my

* *De Rer. Nat.* ii. † *Physiol.* v, 3, 99.

rose bushes and me. Standing there side by side taking the same soil and air one as another, yet this one stays 'Maréchal Niel' and that one 'Gloire de Dijon'. So too, you and I, Cleanthes, may share the same slice of breakfast toast and butter, and your piece will become Cleanthes and my piece Philo, and one is destined to think in terms of beneficent Design, the other in terms of materialist Determinism. Physiology says every item of our body is renewed within a certain space of weeks or months or years. We are no longer in that age, when the comment of the learned on Roger Bacon's famous woman of Norwich who fasted for 20 years, was that to fast is no more marvellous than to need to eat.* We have to be renewed, and our renewal is from energy-systems not in ordinary parlance alive. An instance of the scale of this creating, so to call it, of living matter from non-living, is what happens with the living speck of the egg-cell. In the course of 9 months this speck grows to a living bulk 15,000 million times greater than it was at outset. This increment of living energy-system has been created from non-living energy-systems under the starting influence of a tiny speck which is alive. As that initial speck was specific so is the whole train of increment. Even more it is personal, John Brown or Mary Smith, with a personality, inalienably patterned on that of the initial speck.

"Now such a transition from lifeless to living is thinkable if it be at root an affair of chemical rearrangement. But as transition from one fundamental category of things to another fundamentally different one it is unthinkable. The living and the lifeless studied as energy present no difference that rearrangement of their parts will not account for. The transition between them will be reversible, lifeless-living, living-lifeless, as in fact we know it is.

"We must not, however, think it quite the gross affair our physiologists of last century seemed to leave it at. It is not just a question of a quantity of energy supplied in standard patterns, carbohydrate, fat and protein, together with a little mineral salts. A diet cannot be valued simply by calories as a town gas-supply by therms. A diet with sufficiency of calorie-value

* N. Oresme, *Quodlibeta*, 1370. See L. Thorndike, *Hist. of Mag.* III, 456.

and correct quantities of the standard chemical patterns may yet be inadequate, though it become adequate on adding a very little raw milk. Observing this, the idea opened before Hopkins that there was a question of food-factors hitherto unrecognized though indispensable for a fully nutritive diet. It was shown that a whole menu of the classical chemical entities might yet not sustain animal growth until a little of an undiagnosed specific food-factor was added (Osborne and Mendel). To those who made such experiments it became clear that a healthy diet asked for certain substances not yet identified by the chemist, but needful for health, although in minute quantity. Instances multiplied. The unidentified indispensables became called 'vitamins'. Some quarters, in continental Europe, were slow to follow the lead. They did not admit the existence of such bodies. They were thought 'ill-defined hypothesis'. Time has answered by demonstrating six pure chemical substances, isolated and of ascertained chemical constitution; three of them already actually synthesized in the laboratory.

"The vitamins are now some dozen in number. They prove to be no homogeneous chemical group. If you ask me, Cleanthes, for a definition of a vitamin, all that I, who am no chemist or physiologist, can offer is that it is a something of the class the chemist calls 'organic', which, although in minute quantity, our life wants over and above the mass-fuel of carbohydrates, fats and protein, and wants presumably for particular and specific pieces of its chemistry. Unversed as I am, the position reminds me of an old popular view once voiced by the shibboleth 'phosphorus for the brain'. I fancy there the brute fact was that our brain contains phosphorus compounds, and we can add a phosphorus compound to our breakfast food; and that there the argument stopped. With a vitamin, however, an ascertained bodily faculty—to use Jean Fernel's word—is found to need it and to fail when the food does not contain it, or enough of it, and to recover when the food does supply it.

"There is that child, your neighbour's child, Cleanthes, whom it is pleasant to see with its grace of bearing and the dainty teeth it speaks across. Its parents' care and good circumstances have provided it, Lady Mellanby might tell us, with a fairy god-mother called vitamin D. A good fairy presiding over the bone-forming salts and the formation and arrangement of the teeth, and keeping away dental caries. It is a charm against rickets. And now well enough known and recognized to be prepared in purity on a practical scale; and to be assayed in international units at the National Institute for Medical Research, where indeed its purification was first accomplished. It had no established place in the idea of diet a generation ago. And there is vitamin A, a good angel for growth and against bacterial infection. It occurs more liberally in ordinary foods, in butter and eggs and green-food. But it depends on sunlight, and on rays in sunlight which our ordinary window-glass does not transmit. It requires the sun and is best from May to September. There is therefore a seasonal variation of it in the dairy-produce our diet draws on. It, too, is obtainable pure and is assayed in international units. These are but samples. There are vitamin B, vitamin C, vitamin E, and B is a whole group in itself, B 1, running to B 6, a 'full-sized swarm'. Each of them all contributes its something toward health. Thus, lack of one brings scurvy, lack of another rickets, of another polyneuritis, of another a form of sterility. You are smiling at the unfairy-like names of these good fairies. Their names were non-committal in order that scientific ignorance should not be cloaked. Under fuller knowledge they are already being re-christened properly and chemically. Vitamin C is ascorbic acid (Szent-Györgyi), and is generally so spoken of. Vitamin A is β-carotene.

"All this has been a fine step in human knowledge, Cleanthes. Man is a disturber of the ways of life on his planet and not least a disturber of his own ways and old habits. Not so long since we were content with flour from the near wind or water-mill and we got milk from a near farm. Now we insist on flour more white and refined, and our milk is conveniently canned and condensed for distribution and storage. But these do not as did those protect any longer from ill-nutrition and scurvy and bacterial infection. Time's compensation is that we have now fresh fruit and green-stuff accessible and available by modern transport and cold-storage from distances and in seasons undreamed of in those former times. Our own wishfulness tied us up in difficulty which our own hands are now untying. If I dare speak for our race, Cleanthes, that has happened before: 'à longue échéance', our detecting the vitamins is a further step towards our exploiting the planet, and to do that we must do as none of our sub-human predecessors ever had wit to do, we must take Claude Bernard's advice, and carry our own particular environment with us. To do that we must know adequately what that environment is, and now we know the vitamins belong to it.

"The knowledge has come opportunely, but it has had its difficulties. Their quantitative slenderness was one stumbling block in the path toward detecting the vitamins. A sufficiency of vitamin A for twelve dozen rats their life long is half a drop of its 5 % solution. And not only is their amount escapably small but they are chemically fragile, and difficult therefore of chemical detection and isolation. We reckon the vitamins to food. But food such as sugars, fats, and we may add proteins, are of calorie-importance. The small amount in which a vitamin is effective is not understandable on its global energy-value or calorie-value. We have to think their rôle rather as supply and renewal for some specific pattern or part-pattern in an organic molecule essential to certain cells. It may be that they are indispensable for certain catalyses. Vitamin B, which counteracts nerve-degeneration is a so-called co-enzyme in oxidation (of pyruvic acid) in the brain (Peters).

"Many of us no doubt got on well enough before any study of the vitamins. The gourmet, Cleanthes, may not extol them even now. Nor presumably have they mattered much where, as with your neighbours and their child, the circumstances at their command supply a plenty and variety which, even unwittingly, embrace the whole quota of the vitamins. But the community at large has some of its children in sunless dwellings and some of their parents without the means of plenty. The study of the vitamins arms a community for instituting a nutrition sheet 'planned to safeguard the health of every citizen'* and his children. That also is a step toward our inheriting the planet we inhabit.

"It was a capital step of progress to find that our dieting was not so simple a matter as we had thought it. We had eaten and drunk somewhat as M. Jourdain had talked prose, without

* L. Hogben, *Science for the Citizen*, p. 918, 1938.

understanding the complexity of what we did. The replenishing of the living from the non-living is a more ticklish affair than we had light-heartedly supposed. Or perhaps we had left that mysterious transition from non-living to living as too akin to the miraculous to be understandable by us as process. That mysterious passage from 'lifeless' to 'living'—to 'life', the indefinable, the inexplicable! Life, we know, can be fed with matter, but for us to comprehend that matter's becoming 'alive', to trace it 'en passage' from one category of nature to another? Is it to be expected we should trace it? What question is there we can put to it about its change as it passes across the boundary from 'dead' to 'alive'? Yes; but suppose, Cleanthes, that boundary be a figment? The passage then too becomes imaginary. The difficulty becomes an imaginary one. Chemical partial repatterning might then be all, and quite intelligible to the chemist. The vitamins, too, drop then into their several places."

For Fernel, however, that the living body should be replenished and indeed formed wholesale from material which was non-living before incorporated, and then on incorporation became alive, would hardly need comment. It offered no difficulty where an immaterial life-principle tenanting the body vivified it all.

Recruitment of living from lifeless is going on in almost endless variety on land, in sea, and river, and unceasingly. But in all its instances its starting-point is already existent life. Every search for any other starting-point has failed. The individual as observed is always a bud from a previous one. This is an observational position relatively newly reached. Aristotle had no expectation of it. Nor had our physician-philosopher Fernel some eighteen centuries later. A century later yet William Harvey had glimpsed it; "The living thing", he said, "is always from an egg, which again is always from a living thing." Later the problem assumed great practical importance from certain applications. It was seen that the essential fermentation-processes at root of many branches of industry (wine-production, farming, manufacture, and others), were due to microscopic lives springing up in the material used. If these arose not *de novo* but solely from specific seeds, then by controlling the access of wrong seeds, manufacture could be controlled and improved. Pasteur found that in no case did the germs arise *de novo*; that is, there was no 'spontaneous generation'.

It is impossible to prove a negative, but he challenged the world to show a positive contradicting his negative. The world has been trying to do so ever since on a colossal scale, for instance, through the fermented-liquor industries of the united world. But Pasteur's negative stands unshaken. Again, Lister showed that the suppuration of wounds, erysipelas and septicaemia, and puerperal fever and so on, were similarly due to germs. Like Pasteur, he too never found the germs arise *de novo*. On the assumption that they never do, he devised measures for keeping their seeds out of the wounds. He banished suppuration and septicaemia from surgery. His negative statement that these myriadfold new individual germ-lives never arise except from pre-existing ones is being tested every minute over the civilized world—and no exception is found. If ever a negative came near proof, this may claim to do so. In so doing it rescues every year scores of thousands of human lives from suffering.

We may imagine this time Cleanthes turning to Philo. "Philo", he might say, "if matter, or as you prefer to call it 'energy', did this thing, that is produced life of itself, years ago, why should it not continue to do it now? Perhaps, despite the evidence, you think it still is producing it?" Philo we can suppose to shake his head, and for reply remark "the conditions are not the same now as once". To which Cleanthes rejoins "They are favourable to life now, and that is what you say they were then." We can hear Philo mutter, "a matter of substrate and ferment". But to Cleanthes it had more in it than that.

Of behaviour observable in the cell, does any lie beyond the capabilities of matter according to today's conception of it? We are told today by some of those whose study it is, that practically the whole behaviour of matter is electrical. Cohesion, inertia, light, heat, chemical affinity, all are ultimately electrical. Matter almost resolves itself into the electrical. Electrical charges move from or toward one another, a behaviour which is transfigured into the metaphor, they 'attract' or 'repel', they do so in regular ways, which is transfigured into the metaphor, 'they obey certain laws'. They group themselves into certain types of systems, groups called atoms, because for a time thought indivisible like the speculative particles of the ancient 'atomists'. These groups can be broken up into their components and be reassembled. Again sets of groups are formed by the so-called atoms arranging themselves into further systems, molecules. They are electrical systems, as are the atoms gathered together in them. These groups make up aggregates whose behaviour presents itself in bulk as solidity, fluidity, colloidal state and the whole gamut of physical states. It is in accord with certain aspects of this behaviour that some mixtures of molecules arrange themselves as a complex of phases, the colloid state, with molecular aggregates often of molecules of great complexity. The colloidal state plays a great part in the living cell. As compared with some particles of the colloidal state, the smallest unit-lives themselves are but little larger. They are, however, all of them large enough to contain a number of molecules of the chemical classes, protein, fat and carbohydrate. These are commonly associated together in the organization of a complex which is said to live. Electrical charges grouped to atoms, atoms grouped to molecules, molecules grouped to aggregates of molecules, and, with this grouping reached, some of the smaller and more unstable of these aggregates balance their loss of energy for a time by taking fresh. Shall we suppose that anything has entered into this material to make it, unlike all the preceding organizations of matter, something over and above matter?

The cell feeds. The amoeba of the pond and the amoeboid cell of our blood, can be seen to take particles from the fluid around, and digest them. Is that to be accounted for by the properties of mere matter? These cells, seen by the microscope, are each a granular lump of jelly, continually changing shape. Changes in the surface-tension and the surface-charge at the interface between the cell and the watery fluid could account for this changing of shape, as it does with the meniscus of a capillary electrometer. That changes in the surface-charge should occur is in agreement with the cell's chemistry. It is an extremely active chemical field. That the cell should make movements of its own is an outcome of such charges. With these movements the cell has a means of feeding itself. Subject it to steamtemperature for a minute; the movements cease, not to return. We may say the heat has 'killed' it. The movements were living movements. Chemistry, not knowing the word 'life', says the proteins are irreversibly altered. The native protein-complex was a condition of those movements. The internal chemistry is altered. The cell feeds no more. Those movements were part of its feeding. Extrusions of the cell flowed toward the particle and round it. They engulfed the particle. Round the engulfed particle within the cell the fluid of the cell turns acid. The particle dissolves as it would within our own digesting stomach, likewise acid. There would seem in all this, remarkable as it is, nothing which the chemical system of the cell does not of itself carry through as chemistry. It can be conducted in absence of 'life' in a test-tube in the laboratory.

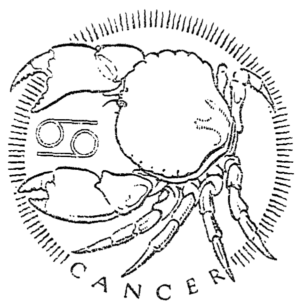
But the cell seems to *choose* some particles by preference. As a specialized chemical system the cell will react differently to particles chemically different. The cell's surface-tension alters in the neighbourhood of a sapid particle, as is understandable if the particle has any 'atmosphere' of solution round it. Even with simple acid and alkali the cells swarm to one or the other, obeying chemical principles entirely. It is the chemistry of a wound which directs our defensive cells thither. Mechanically injured cells extrude these substances which attract the amoeboid cells of the blood. That is verified by fact. The fluid moistening the abdomen does not attract them if the abdomen is healthy, but when the abdomen's lining membrane is irritated by the presence of foreign matter, or is inflamed, its fluid at once acquires the property of attracting the amoeboid cells of the blood.* Again, injured muscle attracts the amoeboid cells, but uninjured does not. Their behaviour is not confined to indifference or attraction; it includes avoidance. Chicken cells are found actually to avoid healthy mouse cells. But injured cells, even if mouse cells, they run for. If we watch a pond amoeba we notice that some of the particles it eats are not food; but most are. With a chance collection of particles presented to it some of these particles modify the streaming of its cell substance, and these are eaten. A chemical atmosphere,

* C. G. Grand and Robert Chambers, *J. Cell. Comp. Physiol.* 1936, ix, 172.

so to say, surrounds a particle, different for different chemical kinds of particles. A chemical atmosphere seems to surround amoeba itself. Observers describe how the quick little *Colpidium* is captured by the slow amoeba. It swims as though attracted into the 'mouth' of amoeba. It is the chemical behaviour of the invading bacteria which brings our amoeboid cells thither to engulf and digest them. Our amoeboid cell as a physico-chemical system will treat the wound and the germs of disease as chemical factors and, doing so, do just what it does. And, so doing, defend the body. So obvious and significant is this last, that the surgeon watching and studying the behaviour of the cells, though knowing it chemical, calls it 'defensive', as if it were inspired by purpose.

Does the cell, freely moving in the pond or in our body, *seek* its food? Is there some modicum of mind in it? That is a question natural to ask. It is not decisively answerable. It has seemed to some patient observers that the free single cell, for instance paramaecium, can be trained to some extent. That is, that it can learn. In short such behaviour is modifiable, and carries the inference that the modification is due to individual experience. If by experience here we mean mental experience, we may, I think, while not doubting the description of the observations, doubt this inference from them. Not that there would seem any inherent unlikelihood in mind attaching in some degree to an individual consisting of one single cell. What was it Hobbes said? "I know there have been certain philosophers, and they learned men, who have held that all bodies are endowed with sense; nor do I see, if the nature of sense be set alongside reaction solely, how they can be refuted."* The improbability is, however, that mind of such degree should be recognizable by us as mind.

* *Element. phil.* iv, 25.



IV

THE WISDOM OF THE BODY

Or a giggle at a Wonder. KEATS.

Anatomize the eye: survey its structure and contrivance; and tell me, from your own feeling, if the idea of a contriver does not immediately flow in upon you with a force like that of a sensation.

HUME'S *Dialogues concerning Natural Religion*, Edit. KEMP SMITH, p. 191.

I remember well the time when the thought of the eye made me cold all over.

CHARLES DARWIN.

L'admiration est toujours une fatigue pour l'espèce humaine.

Le Bal de Sceaux.

IV

We dismiss wonder commonly with childhood. Much later, when life's pace has slackened, wonder may return. The mind then may find so much inviting wonder the whole world becomes wonderful. Then one thing is scarcely more wonderful than is another. But, greatest wonder, our wonder soon lapses. A rainbow every morning who would pause to look at? The wonderful which comes often or is plentifully about us is soon taken for granted. That is practical enough. It allows us to get on with life. But it may stultify if it cannot on occasion be thrown off. To recapture now and then childhood's wonder, is to secure a driving force for occasional grown-up thoughts. Among the workings of this planet, there is a *tour de force*, if such term befits the workings of a planet. Wonder is the mood in which I would ask to approach it for the moment.

The body, we said, is made up of cells, thousands of millions of them, in our own instance about 1000 billions. It is a unity which has become multiplicity while keeping its unity (Carrel).* At its beginning it is just one cell, and the whole body is the progeny of that one. Hence the whole body is a million-membered family of cells whose ancestry converges back to that one ancestral cell, whose progeny it was. And that, in its turn, was from the ancestral cell of a next preceding organized family of cells. We are each and all of us instances of such families.

In each generation the impetus for the initial cell to produce its organized family is supplied by the coming together of it and another cell, outside its own familial stock, but not too far outside. In our own case and in the case of all our nearer kind, these two cells come from individuals of like species. The two individuals have to be complemental in sex. The fertilization-process which is preliminary to the train of growth of a new individual—what Fernel might have called its efficient cause—our description can dispense with, although it is highly in-

* *Methods of Tissue Culture*, by R. C. Parker, foreword by Alexis Carrel, 1938.

teresting. The story of growth from a rounded microscopic speck to a shaped creature, is what we will glance at in outline. It is a story without parallel outside the world of life. Tracing it, even very briefly, we can then turn to judge of controversy about it. Before the coming of the microscope the earliest chapters of this life-story baffled the wisest. They were mere conjecture. When the microscope did come it set itself to trace this Odyssey, this journey from a pin's-head egg to a grown man. Some saw as the starting-point of it an infinitesimal man. But that mistake was soon dispelled; the truth was stranger still. All there was to see was a speck of granular jelly, bearing no likeness to either parent or to man at all and no hint even of whether plant or animal, fish, fowl or mammal.

Then at its outsetting that speck grew and, presently tearing its tiny self in two, made an adhering pair. Then they 4, 8, 16, 32 and so on; only to slow down after reaching millions upon millions. Not to stop altogether until by misadventure or, after years, by natural term, there falls on the whole assembly that subversive change called 'death'. So is made plain how it comes that the adult individual is nothing but an assemblage of cells. Each of the cells from the beginning besides shaping itself takes up for itself a right station in the total assembly according to the stage which the assembly has by that time attained. Thus each cell helps to shape, and to construct as by design, the total assembly and the assembly's ordering of the moment. So it is that those early thirty-two cells dispose themselves as a little ball, hollow and filled with water. These thirty-two cells then are a beginning stage of the individual to be, and the beginning whether beast or man.

Their visible arrangement taken at that stage gives practically no obvious hint of what the ultimate will be. Thence quickly, though gradually, change sweeps onward to later stage on stage. Darwin quoted the naturalist who wrote, "I have two little embryos in spirit, to which I have omitted to attach names. I am now quite unable to say to what class of animals they belong." Lizards or birds or mammals, they might be any of them. That kind of thing must have confronted Aristotle as a biologist; it may account for his habit of stressing a *final* cause. He insisted that to know a thing its final term must be known; in other words to know it we must know whither it is going. That was an injunction which Jean Fernel accepted from him and endorsed. In biology to jump at the final causes has many times led to mistakes. It did so notably with Galen. But it has also often solved problems. What it has achieved in biology does not permit us to despise it. It opened clues to Harvey. But in following it, Harvey never forgot that its following as a clue demands control by other evidence at every step.

The successive chapters of the story of the little ball of cells is like a serial transformation scene. The little ball can be likened, crudely enough, to a set of magic bricks. The one cell, the original fertilized cell, grows into two and those two each into two, and so forth. When that has gone on in the aggregate some 45 times there are 26 million million magic bricks instead of one. That is about the number in the human child at birth. They have arranged themselves into a complex, which is a human child. Each cell in all that more than million-fold population has taken up its right position. Each has assumed its required form and size in the right place. The whole is not merely specific but is a particular individual within the limits of the specific.

In that individual, that 'persona', each cell has taken on the shape which will suit its particular business in the cell-community of which it is a member, whether its skill is to lie in mechanical pulling, chemical manufacture, gas-transport, radiation-absorption, or what not. More still, it has done so as though it 'knew' the minute local conditions of the particular spot in which its lot is cast. We remember it is blind; senses it has none. It knows not 'up' from 'down'; it works in the dark. Yet the nerve-cell, for instance, 'finds' even to the finger-tips the nerve-cell with which it should touch fingers. It is as if an immanent principle inspired each cell with knowledge for the carrying out of a design. And this picture which the microscope supplies to us, conveying this impression of prescience and intention, supplies us after all, because it is but a picture, with only the static form. That is but the outward and visible sign of a dynamic activity, which is a harmony in time as well as space. 'Never the time and the place and the "agent" all together.'

Here all three and always, save for disease. And dominating forces as diverse as powerful.

In its earliest stage the embryo's cells are not notably different from one another. Later a finished muscle-cell and a finished nerve-cell and a finished liver-cell are as far apart in visible structure as in what they do. They become so in spite of being by descent all members of one family. On the other hand, take of each similarly-functioning cells a pair, one from man and one from fish, and, though by descent worlds apart, the observer can read at a glance that members of a pair, alike in what they do, conform to the same pattern. The nerve-cell is as obviously a nerve-cell whether from man or fish. The dynamic stresses which so force apart and so draw together must be powerful indeed. In that way the cells of the various parts of the systematized assembly assume, as need is, special shapes, octagonal, stellate, threadlike, or what not. They, as the case may require, pour out cement which binds, or fluid in which they shall move free; or they hold hands for surer and more sensitive contact. Some will have changed their stuff and become rigid bone or, harder still, the enamel of a tooth; some become fluid as water, so to flow along tubes too fine for the eye to see. Some become clear as glass, some opaque as stone, some colourless, some red, some black. Some become factories of a furious chemistry, some become inert as death. Some become engines of mechanical pull, some scaffoldings of static support. Some a system transmitting electrical signs. Each one of all the millions upon millions finally specializes into something helpful to the whole. It might serve as a text for democracy. It is as if the life of each one of all those millions has understood its special part. Thus arises the new integral individual to be.

To this there seems at first sight one exception. One cell-type which, out of all the myriads, alone remains its original self and does not specialize. It retains the old original nature of the ancestral cell. Its sisters and their progeny pass on through chains of metamorphoses to form a world of different shapes and activities. But this one persists still unmodified and true to its own primitive forbear. In a word it and its particular progeny remain germinal. It must be so, or there would be no future generation of the entire stock. To begin again there must be a return to the beginning. There is but this type to carry the whole family, as we termed it, on to a further generation. All its sisters with their flights into far-fetched specializations, including the brain with its mysteries of mind, are powerless to produce again a germ such as they sprang from. From no one of them all, let them be ever so human, can any fertilization produce their like again in the shape of man or human child. For that their sister cell, still generalized like the ancestral cell, is the sole means remaining. Hence from the old ancestral cell one narrow derivative line of descendants, nested in the rest of the immense specialized collateral progeny, retains its original germinal and general nature; and even this has to ripen. Significantly enough it then sets itself free from all the others. And so from generation on to generation. This limited cell-stock which can be called exceptional in that unlike its congeners, it does not specialize away from the parent germinal form, can be thought of as no exception after all. It is specialized for reproduction. It is clearly specialized in so far that only a special fertilizer can fertilize it. Its own specialization, as though by foreknowledge, anticipates among other anticipations what the nature of that special fertilizer will be. The whole astonishing process achieving the making of a new individual is thus an organized adventure in specialization on the part of countless co-operating units. It does more than complete the new individual; it provides for the future production of further individuals from that one.

More than half a million different species of pattern of life are, I believe, listed by the systematic naturalist as present current life. And each, as we say, 'breeds true'. This particular one we have followed is that to which the pair of cells, which made it, themselves belong, and they will make no other kind. But although of their species it is not quite like any other that ever was, and no other which ever will be shall be quite like it. It is not only man but it is the man John Brown, or the woman Mary Smith, whose exact like never was yet. This that pair of cells did as if they had been taught beforehand and many times rehearsed it. It was done likely enough without a hitch.

But that procession of change which for instance abuts in the human child has never come within the rôle of the actual ancestry of the fertilized cell which sets about it. All that has come within the experience of that ancestry has been the launching from generation to generation of that side-adventure which now terminates in fully completed man; the participation has gone no further than the launching. An explanation once offered for the evolutionary process traced it to 'memory' in the ancestral cell re-living its experiences. But such an explanation rests, even as analogy, on a misapprehension of the actual circumstances. It would be imagination rather than memory which we must assume for the ancestral cell; memory could not recall experience it never had. But the key of the problem is not psychical. Chemistry holds the key.

The few early units which formed the family when it was but a tiny ball take, so to say, into their counsel water. The ball they form is filled with it. The growing membrane, half-floating, can then fold. It shapes itself, it feeds, water is a generous solvent; and it admits electrical activities, chemical compounds separating with opposite charge. Water is the very menstruum and habitat of each and every cell. Water, within and without, allows the cell free scope for action. Water is a wonderful 'surround' and the germinal cell seems to appreciate that.

Water within and water without. The cell-surface becomes at once a boundary and a medium of exchange between two chemical worlds, one inside the cell, 'alive', the other outside it, lifeless. The cells divide and divide and differentiate and differentiate. The total aggregate of the surface between alive and not alive becomes greater and greater, and endlessly qualitatively graded.

Step by step things shape. There appear, tiny at first, what to the eye of the expert are recognizable as rudiments of parts of the future creature. The brain is a set of three little hollow chambers, and, thrust from the hindmost, a short tube, the spinal cord. They were formed by the membrane folding over right and left, the side-flaps merging and so making a tube. Their membrane will come to be a patterned nest of branching cells all in touch directly or indirectly one with the other and, in man, approaching in number our planet's human population. The tubular chamber with its watery content persists, buried within the greatly enriched membrane. It persists throughout life, a primitive vestige, a dumb witness to far primeval times when not only man, but bird and mammal and even reptile had not yet come to be. That early step of folding to make a tube-like brain belongs to the opening chapter of the story of the human embryo growing into a child, but it is a primordial step, which foreran by aeons the advent of the human form itself.

Yet this swift and sure drama at some detail in some scene occasionally fails of full enactment. Sometimes the child is born with its brain and cord not closed to a tube, but lying open as a furrow. Then the nerves, which from all over the body should grow in and make connection with the roof of the completed tube, may be found looking, as it were, for it; and they look for it in the right place. But they themselves are helpless. It is not there. Theirs would seem therefore a blind search. What kind of co-operation is this? Is the whole story just chemistry and physics? The outcome here is evidently that of a process which sometimes goes wrong. Such instances are not very uncommon. Fingers or toes may misgrow club-like together. One kidney may fail. The head may contain practically no brain. In the heart the window between lung-half and other half may not close at birth, so that the blood goes imperfectly aerated, and the child lives half blue with suffocation. What is the meaning of these failures in the issue of the plan? Where two calves of a birth are of opposite sex, the sex-organ of the female twin is found under-developed. Its development is checked by chemical substances which favour the male twin. In the cow the twins in the uterus have a circulation in common and the male hormones circulating through both inhibit the cow-calf. In the human case the circulation is not in common and this does not occur. The blood-supply of each twin is separate. Now, hormones are chemical substances. The instance makes clear that at least in this example chemistry controls the plan of the young creature.

Out of that little hollow ball of cells of the beginning, cells all looking much alike, differentiate and grow heart, brain, gland, muscle, bone, skin, ear, eye; and, threading among them a network of tubelets, carrying the blood into reach of every cell in all the complex body. Also lines of nerves to take nervous messages from skin and ear and eye to spinal cord and brain, and other lines of nerves taking messages from spinal cord and brain out to the muscles. Can chemistry account for it all?

Even in relating this we drop into an old habit. We speak of nerves *for* doing this and that. This is the Galen in us. To do so comes naturally to the lips. And Galen in this was thinking as everyone thinks and was speaking for Mr Everyman, not merely of his own time but for practically ever since. Muscles seem made for what will be wanted of them. In the foetus a short channel joins the root of the lung-artery with that of the main artery of the body. Immediately following birth the lung enters activity, and this side-tracking of its blood-supply would be disadvantageous. A little before the foetus is actually born this channel is shut by a special small muscle. This muscle "as far as is known never used in the foetus," "springs into action at birth" * and shuts the channel. "Having performed its function it degenerates" and disappears, the channel having in due course become obliterated under disuse. Sir Joseph Barcroft adds "it would seem very difficult to claim that the muscle which closes the ductus at birth has been differentiated as the result of any specific conditions to which it has been subjected—much less any specific use which it has subserved".†

Nerves seem *for* their purpose, constructed in view of what *will* be 'wanted' of them. Before ever they function they grow where they *will* be wanted, they make the 'right' connections, those they *should* make. We all drop into this mode of thought; we adopt it as we dissect. In the particular prodigy before us now, that of a microscopic cell becoming a man, we incline to read the whole story in that way. We say 'it grows into' a child. Grows? Levers laid down in gristle, becoming bone when wanted for the heavier pull of muscles which *will* clothe them. Lungs, solid glands, yet arranged to hollow out at a few minutes' notice when the necessary air shall enter. Limb-buds, futile at their appearing and yet deliberately appearing, in order to become limbs in readiness for an existence where they will be all-important. A pseudo-aquatic parasite, voiceless as a fish, yet constructing within itself an instrument of voice against the time when it *will* talk. Organs of skin, ear, eye, nose, tongue,

* *The Brain and its Environment*, by Sir Joseph Barcroft, pp. 73–81. Yale University Press, 1938. † *Ibid.* p. 73.

superfluous all of them in the watery dark where formed, yet each unhaltingly preparing to enter a daylit, airy, object-full manifold world which they *will* be wanted to report on. A great excrescence at one end of a nerve-tube, an outrageously out-sized brain, of no avail at the moment but where the learning of a world which is *to be* experienced will go forward. All seems to argue prospective knowledge of needs of life which are not yet but are foreknown. All is remembered; no detail is forgotten, even to the criss-cross hairs at entrance to a cat's ear which keep out water and flies (Pl. V *a*). Had antiquity or the middle ages been acquainted with the facts, they would have been set down to Natural Magic. Fernel's Preface (1542) wrote "as Aristotle says to know the end of a thing is to know the why of it". And similarly to-day the biologist writes,* "we can only understand an organism if we regard it *as though* produced under the guidance of thought for an end".

Suppose tentatively, at pause before this riddle, we allow the premiss that in this developing embryo there resides some form of mind or psyche, and even in each of its constituent cells, and not inferior to what as human individual it will ever have. Mind so present and intent on producing the child to be, would still be faced at every step with 'how'. It would be helpless. It has no experience or memory to have recourse to for the purpose. It is an aggregate of cells doing what they are doing for the first time and the only time they ever will. Yet every step they take seems fraught with purpose toward a particular end. The purpose clear, the 'how' of it obscure. Watching the limb-bud enlarge and shape without hitch to an arm, the surprise is not when all goes right but when sometimes something goes wrong. A finger fails. The process is fallible! Not the perfection but the freak receives our stare.

The microscope enables a more intimate glimpse. But the microscope merely resolves the mystery into some millions of separate microscopic growing points, each still a mystery. We ask what is the process going on at each of these? Again, how are they all co-ordinated to give a harmony of growth 'according to plan'?

* R. C. Punnett, "Forty years of evolution theory", in Needham and Pagel, *Background to Modern Science*, p. 196. Cambridge, 1938.

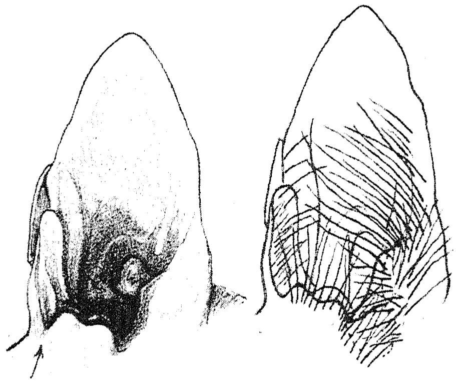


PLATE V*a*. ENTRANCE OF THE CAT'S EAR

Left: shaven to show the contours. Right: the palisade hairs across the entrance, which excite a rhythmic head shake expelling any intruder. The act is reflex.

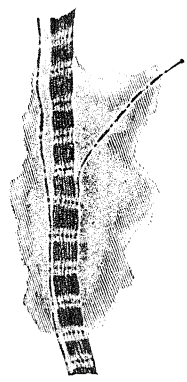


PLATE V*b*. MUSCLE FIBRE

(by courtesy of Messrs. Longmans, Green & Co.)

Growth? The word in biology, employed I suppose since biology first was, took long in getting to grips with its intimate scientific 'how'. Its 'rapport' with chemistry and physics was not close. Its study consorted rather with that of gross visible shape, the shapes of life. Growth is of course a factor in their shaping. To record shape has been far easier than to understand it. The shaping of the embryo taken at its face-value is an amazing 'becoming' which carries 'purpose', even as the wing of the insect or the stream-lining of the whale.

Because atoms combine on the basis of the arrangement of their sub-atomic parts we do not speak of those constituent parts as there *for* producing molecules. We do not speak of electrons as *for* producing atoms. Yet molecule-producing—and atom-producing—would seem as purposive as limb-producing. Our concept of an atom treats an atom as a deterministic necessity. To describe atomic behaviour science makes no appeal to purpose. In physics science would gain nothing by that appeal. Does it in biology?

In the study of biology the integral shape of the living thing has always held a prominent place. Such shape is always specific and of decisive meaning to the life itself.* It was a study which as it became subtler and more conscious of its ultimate aim called itself morphology, so stressing better that it has for its object visible shape. Its technique, like that of anatomy from which it sprang, was, prior to the microscope, simple, requiring a few cutting tools and the naked eye. Hence it had been accessible to antiquity. Aristotle's genius ranging over the field of animal form practically for the first time in science discovered much and laid down philosophic foundations. He possessed, for his era, an encyclopaedic acquaintance with animal form, and he drew from it profound and far-reaching inferences regarding Nature. So too again, 2000 years later, it was comparative study of living shape which furnished Darwin with his main texts for his doctrine of the relatedness of living things by descent.

Aristotle in treating the nature of visible form used regarding it an *a priori* conception. Probably, all circumstances considered,

* See Sir D'Arcy Thompson's *On Growth and Form* for a luminous exposition.

that was well. We can think he got further by that means than he would by any other open to him and his time. Knowledge of material (matter) was too slender then, and for long after, to give him help in such a problem as the shape of living things. It was an age when, as to Nature, zeal for analysis commonly outran the means of factual knowledge. Aristotle argued that a concrete thing, a stone, a cloud, a tree, a man, comprises on the one hand its material and on the other, so to say clothing that material, its form, separable, not merely in thought, from its material. The material was perennial, the form transient, and so on. This, whether as synthesis or analysis, served well enough to be still satisfying in the sixteenth century of our era, as judged from our prototype of that time, Jean Fernel, and many others with him. Even two and a half centuries later it underlay the so-called Nature-philosophy which included, among its naturalists, Goethe. But it and they in its respect were then decadent. It had become part of a cult whose votaries out-aristotled Aristotle in regard to 'form'. It stood with them for a creative élan which brooded in and over living nature. It created and, in creating, it aimed at an ideal. At an ideal leaf; or, in the creation of a vertebrate animal, at an ideal vertebra. It was allied to the 'ideas' of Plato, which Aristotle had discarded. Darwinism came later brushing it and them aside.

As the study of living 'form' became, by means of the microscope, more minute and intimate, regions opened where the naked eye could no longer follow; 'form' was strikingly instanced by the microscopic cell. The study of cell-structure became part of the study of living form. The architecture of the animal was an architecture of its cells in the aggregate. It was the upshot of cell-structure. It was then more clear that gross animate form merely statically studied could not explain itself. Gross form had too long been accepted as static and apart from all the rest of the concrete life throbbing as that was with energy, and therefore motion. The pattern of the concrete life had been accepted too easily as an inactivity, as if it were no part of what the animal 'did'. It had been a study of space-relations in frozen Time. Hence it remained aloof from chemistry and physics. Whereas in fact even those portions of the concrete life which seem the more durable are only temporary equilibria, in an unhalting kinetic system. The "abstraction of structure and function is", happily remarks Professor A. D. Ritchie, "at bottom merely a question of what changes slower or faster".*

There is one aspect of life's shaping which has however always pointed plainly to a dynamics of living form. That is growth. An old commonplace of the text-books used to tell us that although growth is a term applied to crystals as well as to living things, crystal growth affords no clue to and no paradigm for living growth. That seems now too hard and fast a saying. New techniques have recently been enlisted for the examination of biological structure. One of them is that developed by the Braggs for their masterly X-ray analysis of crystal structure and growth. The cell not so long since was plausibly regarded as a colloidal droplet. A drop of amorphous colloidal suspensoid seems as remote as anything possibly can be from what we should call architecture. To appraise the living cell as such a droplet was to forget that the cell is always an organized integer. Its visible structure expresses that. If unified spatial plan is architecture the cell has architecture. As to the stones of its architecture, they are in one word 'proteins'. It is a protein fabric. The nucleus, centering it, is a nodal point for the cell's synthesis of proteins.

As for colloid, the proteins behave in several ways as do inorganic colloids. They are held back by membranes, they diffuse slowly, and so on. Protein particles were not so long since thought colloidal molecular aggregates, not single molecules. For one thing they seemed too large. The chemist for all his synthetic achievements cannot construct any molecule approaching in mass the protein particle. That particle when regarded as a cluster of lesser molecules, was therefore supposed indeterminate in mass. But the protein particle is now at least in many instances known to be one giant molecule. It has the definite individuality which is the hall-mark of a molecule, where every constituent atom is indispensable for the completion of the structure. X-ray analysis yields a picture of the atomic architecture of the protein-molecule, an architecture found well worthy of the name. Likewise the ultra-centrifuge

* *The Natural History of Mind*, p. 183, 1936.

in a different way gives data of the mass and figure of protein particles, and it too finds them to be giant molecules. Some are thread-like, others practically globular. Their potential variety of pattern runs to astronomical figures. The probability nevertheless holds that one underlying style of architecture obtains throughout them. Their wealth of detailed pattern provides a practically inexhaustible* variety for life to build with.

Pure mechanical treatment affects these giant molecules to an extent not evident with smaller and simpler ones. They can be 'denatured', that is warped in configuration, reversibly or irreversibly, by mechanical agitation or even by inclusion in the surface-layer at a boundary. The cell, and therefore the living body, are sponge-works of boundary layers. The protein coat of the fertilized egg-cell which restrains the daughter-cells from becoming spherical behaves as a sheet of elastic jelly. It can be cut by the 'microneedle' without loss of its rigidity. But mechanical agitation by moving the needle back and forth 'dissolves' it locally. The shape of these protein molecules is in certain cases traceably related to the mechanical properties of the animal structure. In wool-keratin the molecule has an extensible backbone which lengthwise pull unfolds to a more open zig-zag. Hence the wool's reversible extensibility. Again, the immense significance of muscle to life rests on its property of changing length and lengthwise tension. This, it is claimed, is due to a protein-molecule of folding and unfolding type.

From the pattern of a molecule to the pattern of a machine seems at first a far cry. Yet if we take as our machine one of those fibres of which our muscles are built up a close connection between the machine and the pattern of its molecule becomes evident. The essential service of muscle to life is, quickly and reversibly, to shorten so as to pull. Its shortening is called 'contraction'. The importance of muscular contraction to us can be stated by saying that all man can do is to move things, and his muscular contraction is his sole means thereto. Each muscle-fibre is a simplified miniature of muscle, in size just visible to the naked eye. A millimetre is $\frac{1}{25}$ inch; a large muscle-fibre may be 15 mm. long and 0·1 mm. across. A muscle

* Prof. Leathes, Pres. Address, Physiol. Sect. B. Ass. 1926.

is composed of bundles upon bundles of its fibres set lengthwise so as to pull on the muscle's tendon. Each fibre is seen by the microscope to consist of strands of lengthwise-running fibrils arranged in packets and bathed liberally in nutritive juice within the fibre. Beyond that, to further degrees of minute structure, the microscope can hardly carry. X-ray examination then continues the analysis. The unit of measurement is the millionth of a millimetre. The ultimate filament then resolves itself in countless lengthwise lines of giant molecules. Each molecule is about 60 $\mu\mu$ long by about 5 $\mu\mu$ thick. Such a molecule is, as molecules go, immensely large; it weighs about 500,000 times the hydrogen-gas molecule. It is a protein (myosinogen), and it is one of the folding molecules which by buckling back on itself becomes shorter. This seems to be the prime-mover of muscular contraction. Minute almost beyond our actual conceiving, its mechanical power is additively organized to a muscle-fibre in numbers which again are almost beyond our conceiving. A cross-section of our sample muscle-fibre would cut 150 millions of them. It is as if for each $mm.^2$ of a muscle's cross-section a set of pullers five times more numerous than earth's entire human population were aligned to pull co-ordinately in one and the same direction. And at the given command they are called into play co-ordinately in time. It is a command issued through the muscle's nerve. It may be a chemical message but it is transmitted electrically.

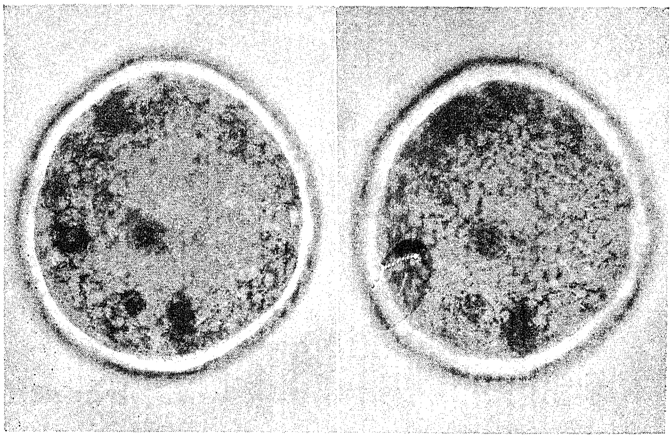
How it induces the molecules in their millions actually to buckle, we have still to wait to know. Suppose however, under electrolytic dissociation, some bends in the myosinogen molecule armed with NH_2 and COOH became alternately oppositely charged (attractive) they would draw together. The zigzag or spiral of the thread would tighten, to its greatest at the isoelectric point of the myosinogen. The mechanism of muscular contraction would then be electrolytic dissociation changing the shape of the protein-molecule. This would agree with the modern rejection of the view of muscular contraction as an oxidation liberating energy for external work. It would make muscle essentially an electric motor, though quite unlike any man-contrived electric motor. Whatever the device nature has contrived it on a number of independent occasions, for instance in the thread-stalk of little vorticella as well as in vertebrate muscle.

I have heard Professor Vivian Hill say that the design of a spade or the gearing of a pedal bicycle are found to have worked themselves out duly proportionately to the rates of performance of the human muscle-fibre. These latter were not scientifically known until Hill's own researches recently determined them. But traditional experience had here allied itself with technology and, although the scientific data were not known, had arrived at the pragmatic right. But when we turn to the muscle-fibre it has solved the incomparably more difficult problem of constructing a prime-mover fitting the biological situation, and it has had nothing mental to assist it, either in the way of tradition or design. That is a sample of the biological problem.

In the embryo, as it grows, gradients of mechanical pull and push as they arise and subside may affect and direct growth and shaping. Ross Harrison, a veteran observer, remarks that such mechanical influence is unmistakable. Chambers finds "Stretching a dividing Arbacia egg longitudinally does not impede its divisions, but stretching it transversely completely stops it" (Pl. VI, figs. 3, 4).*

Such facts stress how central in the problem of animal growth we have to think protein-synthesis. Its mechanism is not well understood. There are however collateral facts which bear significantly upon it. One is that among proteins some are known which reproduce their kind. The instance comes from those submicroscopic agents of disease, called for that reason 'viruses'. Certain of these have been separated in crystalline state—a pledge of purity—and are then found to be proteins of giant molecular weight. These propagate; they reproduce themselves. The mechanism of this multiplication seems a ferment action, e.g. the virus-molecule acting as its own enzyme (ferment). In fine, this protein 'grows'. Again, as though to demonstrate that the self-fermenting protein gives a clue to biological growth, the 'gene', that quintessence of growth, seems to be a self-fermenting protein. The gene is nowadays perhaps too familiar a term to need description here. It may, with some licence, be styled a quantum of heredity. But it has,

* *J. Cell. and Comp. Physiol.* 1938, xii, 2, p. 160.

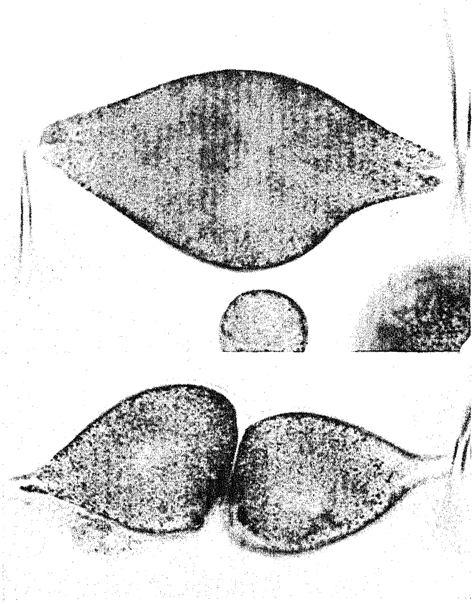
1  2

1. Photograph of a living human egg, unfertilized; magnified about 250 times, focussed near its central plane, showing the general shape, granular yolk, and stout capsule kept tense by the fluid pressure of the contents within. It is one single cell. The clearer area at the centre indicates its nucleus.

2. View nearer the surface.

3

4



3 and 4. Egg of sea-urchin proceeding to multiply by division. Artificially applied stretch in the line of the cleavage-plane completely arrests the self-division. Stretch at right angles to that does not. Professor Robert Chambers' experiment performed by means of microscopic needles.

PLATE VI

with further licence, to be thought of as a seed which planted, though a quantum, grows. Each gene in the egg-cell embodies a unit 'character' in the make-up of the individual springing from the ovum. The gene is no creation of mere fancy. It is a concept which relates, on experimental evidence, a particular hereditary character in the developed individual to a particular visible point in the nucleus of the egg-cell. Each multiplication of the fertilized egg-cell carries with it a multiplication of the gene. The gene in the growth of the body may multiply to some billions of its original. It is situated in one of the nuclear threads. The nuclear threads are thought of as containing strings of genes. The estimated size of the gene makes it of the same order of size as a giant protein-molecule. A cell-nucleus is known to be a nest of ferments. The gene, thus conjectured to be a self-fermenting protein-molecule, is a master-builder both of plant and animal.

Experiment indicates that the abrupt change in transmitted 'characters' spoken of in genetics as 'mutation' can be brought about by 'radiation' applied to a gene. A modification of the gene-molecule induced by absorption of an energy-quantum would seem then to reproduce itself under the self-fermentation of the molecule. The mutation would be a 'quantal-step'. The rate of production and reproduction of cell-substance under growth can be very high indeed, but in the hands of catalysts (enzymes) that is not surprising. In 10 seconds an organic catalyst will activate nearly 10,000 times its own weight of hydrogen peroxide. In a quarter of an hour the nucleus of an actively secreting cell will yield an amount of 'enzyme' nearly equal in volume to itself, in this case not for retention in the cell. Where synthesis, for instance protein-synthesis, is adding to the cell-system itself the cell *has* to multiply, for one thing because the necessary give and take between the cell and its surround sets an upper limit to the ratio cell volume/cell surface. This helps to illustrate how truly a cell is an integer in the living aggregate of the individual.

Its protein-synthesis is a determinant not merely of the living individual's brute bulk but of the individual's, so to say, vital shaping. A motion-picture photographed from cells in growth almost startles us by the intensity of the activity they show. Protein-synthesis is in flood—a riot of activity, but always an ordered riot. The specificity of enzymes is an element of mechanism which carries order far.

The mechanism of the shaping of the 'house of life' remained long refractory to enquiry. It remained plausibly a vitalistic mystery. It seems at last in process of yielding itself up to science. It becomes interpretable in terms of energy, along with other aspects of the body. For Aristotle 'form' stood at least for an activity in the life it shaped. Today again it is seen as an activity; this time in the main a chemical response on the part of that energy-system which is the concrete life. The body of a worm and the face of a man alike have to be taken as chemical responses. The alchemists dreamed of old that it might be so. Their dream however supposed a magic chemistry. There they were wrong. The chemistry is plain everyday chemistry. But it is complex. Further, the chemical brew, in preparation for it, Time has been stirring unceasingly throughout some millions of years. And in the preparation of it Time has rejected much. The brew is a selected brew.

Can then physics and chemistry out of themselves explain that a pin's-head ball of cells in the course of so many weeks becomes a child? They more than hint that they can. Bearing in mind their hints, let us turn to another sample. They claim to be the makers of the eye. A somewhat trite example, it has this difference from the more general problem. It samples, though in little, one aspect of that problem with especial clearness. A highly competent observer, after watching a motion-film photo-record taken by the microscope of a cell-mass in the process of making bone, writes his impression thus: "Team-work by the cell-masses. Chalky spicules of bone-in-the-making shot across the screen, as if labourers were raising scaffold-poles. The scene suggested purposive behaviour by individual cells, and still more by colonies of cells arranged as tissues and organs." * That impression of concerted endeavour comes it is no exaggeration to say with the force of a self-evident truth. The story of the making of the eye carries a like inference, perhaps even more vividly, the demand made on precision of construction being in the eye the greater.

* E. G. Dru Drury, *"Psyche and the Physiologists" and other Essays on Sensation*, p. 4, London, 1938.

The eye's parts are objects familiar even apart from technical knowledge and have evident fitness for their special purposes. The likeness to an optical camera is plain beyond seeking. If a craftsman sought to construct an optical camera, let us say for photography, he would turn for his materials to wood and metal and glass. He would not expect to have to provide the actual motor power adjusting the focal length or the size of the aperture admitting light. He would leave the motor power out. If told to relinquish wood and metal and glass and to use instead some albumen, salt and water, he certainly would not proceed even to begin. Yet this is what that little pin's-head bud of multiplying cells, the starting embryo, proceeds to do. And in a number of weeks it will have all ready. I call it a bud, but it is a system separate from that of its parent, although feeding itself on juices from its mother. And the eye it is going to make will be made out of those juices. Its whole self is at its setting out not one ten-thousandth part the size of the eye-ball it sets about to produce. Indeed it will make two eyeballs built and finished to one standard so that the mind can read their two pictures together as one. The magic in those juices goes by the chemical names, protein, sugar, fat, salts, water. Of them 80 % is water.

Water is a great menstruum of 'life'. It makes life possible. It was part of the plot by which our planet engendered life. Every egg-cell is mostly water, and water is its first habitat. Water it turns to endless purposes; mechanical support and bed for its membranous sheets as they form and shape and fold. The early embryo is largely membranes. Here a particular piece grows fast because its cells do so. There it bulges or dips, to do this or that or simply to find room for itself. At some other centre of special activity the sheet will thicken. Again at some other place it will thin and form a hole. That is how the mouth, which at first leads nowhere, presently opens into the stomach. In the doing of all this, water is a main means.

The eye-ball is a little camera. Its smallness is part of its perfection. A spheroid camera. There are not many anatomical organs where exact shape counts for so much as with the eye. Light which will enter the eye will traverse a lens placed in the right position there. *Will* traverse; all this making of the eye which *will* see in the light is carried out in the dark. It is a preparing in darkness for use in light. The lens required is biconvex and to be shaped truly enough to focus its pencil of light at the particular distance of the sheet of photosensitive cells at the back, the retina. The biconvex lens is made of cells, like those of the skin but modified to be glass-clear. It is delicately slung with accurate centring across the path of the light which *will* in due time some months later enter the eye. In front of it a circular screen controls, like the iris-stop of a camera or microscope, the width of the beam and is adjustable, so that in a poor light more is taken for the image. In microscope, or photographic camera, this adjustment is made by the observer working the instrument. In the eye this adjustment is automatic, worked by the image itself!

The lens and screen cut the chamber of the eye into a front half and a back half, both filled with clear humour, practically water, kept under a certain pressure maintaining the eye-ball's right shape. The front chamber is completed by a layer of skin specialized to be glass-clear, and free from blood-vessels which if present would with their blood throw shadows within the eye. This living glass-clear sheet is covered with a layer of tear-water constantly renewed. This tear-water has the special chemical power of killing germs which might inflame the eye. This glass-clear bit of skin has only one of the four-fold set of the skin-senses; its touch is always 'pain', for it should *not* be touched. The skin above and below this window grows into movable flaps, dry outside like ordinary skin, but moist inside so as to wipe the window clean every minute or so from any specks of dust, by painting over it fresh tear-water.

We must not dwell on points of detail; our time precludes them, remarkable though they are. The light-sensitive screen at back is the key-structure. It registers a continually changing picture. It receives, takes and records a moving picture life-long without change of 'plate', through every waking day. It signals its shifting exposures to the brain.

This camera also focuses itself automatically, according to the distance of the picture interesting it. It makes its lens 'stronger' or 'weaker' as required. This camera also turns itself in the direction of the view required. It is moreover contrived as though with forethought of self-preservation. Should danger threaten, in a moment its skin shutters close protecting its transparent window. And the whole structure, with its prescience and all its efficiency, is produced by and out of specks of granular slime arranging themselves as of their own accord in sheets and layers, and acting seemingly on an agreed plan. That done, and their organ complete, they abide by what they have accomplished. They lapse into relative quietude and change no more. It all sounds an unskilful overstated tale which challenges belief. But to faithful observation so it is. There is more yet.

The little hollow bladder of the embryo-brain, narrowing itself at two points so as to be triple, thrusts from its foremost chamber to either side a hollow bud. This bud pushes toward the overlying skin. That skin, as though it knew and sympathized, then dips down forming a cuplike hollow to meet the hollow brain-stalk growing outward. They meet. The round end of the hollow brain-bud dimples inward and becomes a cup. Concurrently, the ingrowth from the skin nips itself free from its original skin. It rounds itself into a hollow ball, lying in the mouth of the brain-cup. Of this stalked cup, the optic cup, the stalk becomes in a few weeks a cable of a million nerve-fibres connecting the nerve-cells within the eye-ball itself with the brain. The optic cup, at first just a two-deep layer of somewhat simple-looking cells, multiplies its layers at the bottom of the cup where, when light enters the eye—which will not be for some weeks yet—the photo-image will in due course lie. There the layer becomes a fourfold layer of great complexity. It is strictly speaking a piece of the brain lying within the eye-ball. Indeed the whole brain itself, traced back to its embryonic beginning, is found to be all of a piece with the primordial skin—a primordial gesture as if to inculcate Aristotle's maxim about sense and mind.

The deepest cells at the bottom of the cup become a photo-sensitive layer—the sensitive film of the camera. If light is to act on the retina—and it is from the retina that light's visual effect is known to start—it must be absorbed there. In the retina a delicate purplish pigment absorbs incident light and is bleached by it, giving a light-picture. The photo-chemical effect generates nerve-currents running to the brain.

The nerve-lines connecting the photo-sensitive layer with the brain are not simple. They are in series of relays. It is the primitive cells of the optic cup, they and their progeny, which become in a few weeks these relays resembling a little brain, and each and all so shaped and connected as to transmit duly to the right points of the brain itself each light-picture momentarily formed and 'taken'. On the sense-cell layer the 'image' has, picture-like, two dimensions. These space-relations 'reappear' in the mind; hence we may think their data in the picture are in some way preserved in the electrical patterning of the resultant disturbance in the brain. But reminding us that the step from electrical disturbance in the brain to the mental experience is the mystery it is, the mind adds the third dimension when interpreting the two-dimensional picture! Also it adds colour; in short it makes a three-dimensional visual scene out of an electrical disturbance.

All this the cells lining the primitive optic cup have, so to say, to bear in mind, when laying these lines down. They lay them down by becoming them themselves.

Cajal, the gifted Spanish neurologist, gave special study to the retina and its nerve-lines to the brain. He turned to the insect-eye thinking the nerve-lines there 'in relative simplicity' might display schematically, and therefore more readably, some general plan which Nature adopts when furnishing animal kind with sight. After studying it for two years this is what he wrote: "The complexity of the nerve-structures for vision is even in the insect something incredibly stupendous. From the insect's faceted eye proceeds an inextricable criss-cross of excessively slender nerve-fibres. These then plunge into a cell-labyrinth which doubtless serves to integrate what comes from the retinal layers. Next follow a countless host of amacrine cells and with them again numberless centrifugal fibres. All these elements are moreover so small the highest powers of the modern microscope hardly avail for following them. The intricacy of the connexions defies description. Before it the mind halts, abased. *In tenuis labor.* Peering through the microscope into this Lilliputian life one wonders whether what we disdainfully term 'instinct' (Bergson's 'intuition') is not, as Jules Fabre claims, life's crowning mental gift. Mind with instant and decisive action, the mind which in these tiny and ancient beings reached its blossom ages ago and earliest of all."

The first and greatest problem vision faces us with is doubtless that attaching to it as part of the matter-mind relation. How is it that the visual picture proceeds—if that is the right word—from an electrical disturbance in the brain? But as a sub-problem of high importance concerning vision comes that of pattern-vision. The study of vision, pursued comparatively in different animal forms, indicates that the primitive vision widely prevalent in simpler forms of life attains merely to the distinguishing of 'light' from 'no light'. It usually reaches the refinement of distinguishing grades of intensity of light. This primitive vision however does not attain to distinguishing shape or figure. It does not arrive at what is called 'pattern-vision'. Our own seeing makes so rich a contribution to the shapes of our world that it is a little puzzling for us to think of un-patterned seeing. To think of colourless seeing is likewise a little difficult; in many creatures, however, sight is colourless.

Over a great diversity of more highly developed vision, the eye supplies a definite image of what it looks at. There we must suppose 'pattern-vision'; without it the optical apparatus would seem wasted. In many cases the eye has means of focussing its image. That gives further development of the well-known relation between nerve and mind, namely that the '*place*' of a stimulated sensual point acts on the mind; whence 'sensual space' with 'local sign'. It holds certainly not least in visual sense. If the sensitive sheet receiving the light-image be arranged as a mosaic of sub-areas corresponding severally with quasi-independent nerve-elements each with its access to 'sense', then any light-image affecting two or more such sub-areas simultaneously begins to have 'shape', or when affecting them successively begins to 'move'. The *spatial* pattern of the image thus acts on the mind. Different patterns acting differently enable mental distinction between them. For instance a moving object tends to 'catch' vision.*

We know enough of pattern-vision in ourselves to recognize that it is the foundation of a perceptual analysis of our visible world which is of supreme service to us. We know enough of our animal kith and kin to judge that in their case it serves not greatly otherwise for them. We must think that in each instance

* *Vide supra*, p. 55.

a great nervous rallying-place for confluent nerve-impulses from the quasi-independent elements of the ocular-sheet and for reactions between them must be appended to the eye. And that is what is found. Serving the eye there are condensed masses of nerve-structure which examined by the microscope are thickets of seeming entanglement, doubtless replete with meaning could we read their scheme. These great nerve-ganglia of vision are familiar to the zoologist. He knows them in the ant, the bee, the squid, and most of all in our own stock, and especially in ourselves. Their complexity in the insect was what amazed even so veteran an anatomist as Cajal.

The human eye has about 137 million separate 'seeing' elements spread out in the sheet of the retina. The number of nerve-lines leading from them to the brain gradually condenses down to little over a million. Each of these has in the brain we must think to find its right nerve-exchanges. Those nerve-exchanges lie far apart, and are but stations on the way to further stations. The whole crust of the brain is one thick tangled jungle of exchanges and of branching lines going thither and coming thence. As the eye's cup develops into the nervous retina all this intricate orientation to locality is provided for by corresponding growth in the brain. To compass what is needed adjacent cells, although sister and sister, have to shape themselves quite differently the one from the other. Most become patterned filaments, set lengthwise in the general direction of the current of travel. But some thrust out arms laterally as if to embrace together whole cables of the conducting system.

Nervous 'conduction' is transmission of nervous signals, in this case to the brain. There is also another nervous process, which physiology was slower to discover. Activity at this or that point in the conducting system, where relays are introduced, can be decreased even to suppression. This lessening is called inhibition; it occurs in the retina as elsewhere (Granit). All this is arranged for by the developing eye-cup when preparing and carrying out its million-fold connections with the brain for the making of a seeing eye. Obviously there are almost illimitable opportunities for a false step. Such a false step need not count at the time because all that we have been considering is done months or weeks before the eye can be used. Time after time so perfectly is all performed that the infant eye is a good and fitting eye, and the mind soon is instructing itself and gathering knowledge through it. And the child's eye is not only an eye true to the human type, but an eye with personal likeness to its individual parent's. The millions of cells which made it have executed correctly a multitudinous dance engaging millions of performers in hundreds of sequences of particular different steps, differing for each performer according to his part. To picture the complexity and the precision beggars any imagery I have. But it may help us to think further.

There is too that other layer of those embryonic cells at the back of the eye. They act as the dead black lining of the camera; they with their black pigment kill any stray light which would blur the optical image. Further they shift their pigment. In full daylight they screen, and at night they unscreen, as wanted, the special seeing elements which serve for seeing in dim light. These are the cells which manufacture the purple pigment, 'visual purple', which sensitizes the eye for seeing in low light.

Then there is that little ball of cells which migrated from the skin and thrust itself into the mouth of the eye-stalk from the brain. It makes a lens there; it changes into glass-clear fibres, grouped with geometrical truth, locking together by toothed edges. To do the required pertains one would think to the optician's workshop rather than to a growing egg. The pencil of light let through must come to a point at the right distance for the length of the eye-ball which is to be. Not only must the lens be glass-clear but its shape must be optically right, and its substance must have the right optical refractive index. That index is higher than that of anything else which transmits light in the body. Well, it is attained. Its two curved surfaces back and front must be truly centred on one and the right axis, and each of the sub-spherical curvatures must be curved to the right degree, so that, the refractive index being right, light is brought to a focus on the retina and gives there a well-defined image. The optician obtains glass of the desired refractive index and skilfully grinds its curvatures in accordance with the mathematical formulae required. With the lens of the eye, a batch of granular skin-cells are told off to travel from the skin to which they strictly belong, to settle down in the mouth of the optic cup, to arrange themselves in a compact and geometrical ball, to turn into transparent fibres, to assume the right refractive index, and to make themselves into a subsphere with two correct curvatures truly centred on a certain axis. Thus it is they make a lens of the right size, set in the right place, that is, at the right distance behind the transparent window of the eye in front and the sensitive seeing screen of the retina behind. In short they behave as if fairly possessed.

I would not give a wrong impression. The optical apparatus of the eye is not all turned out with a precision equal to that of a first-rate optical workshop. It has defects which disarm the envy of the optician. It is rather as though the planet, producing all this as it does, worked under limitations. Regarded as a planet which 'would', we yet find it no less a planet whose products lie open to criticism, in our case from themselves. Equally, on the other hand, in this very matter of the eye the process of its construction seems to seize opportunities offered by the peculiarity in some ways adverse of the material it is condemned to use. It extracts from the untoward situation practical advantages for its instrument which human craftsmanship could never in that way provide. Thus the cells composing the core of this living lens are denser than those at the edge. This corrects a focussing defect inherent in ordinary glass-lenses. Again, the lens of the eye, compassing what no glass-lens can, changes its curvature to focus near objects as well as distant when wanted, for instance, when we read. An elastic capsule is spun over it and is arranged to be eased by a special muscle. Further, the pupil—the camera stop—is self-adjusting. All this without our having even to wish it; without even our knowing anything about it, beyond that we are seeing satisfactorily.

I must not weary you. As wonders, these things have grown stale through familiarity. The making of this eye out of self-actuated specks, which draw together and multiply and move as if obsessed with one desire, namely, to make the eye-ball. In a few weeks they have done so. Then, their madness over, they sit down and rest, satisfied to be life-long what they have made themselves, and, so to say, wait for death.

But the chief wonder of all we have not touched on yet. Wonder of wonders, though familiar even to boredom. So much with us that we forget it all our time. The eye sends, as we saw, into the cell-and-fibre forest of the brain throughout the waking day continual rhythmic streams of tiny, individually evanescent, electrical potentials. This throbbing streaming crowd of electrified shifting points in the spongework of the brain bears no obvious semblance in space-pattern, and even in temporal relation resembles but a little remotely the tiny two-dimensional upside-down picture of the outside world which the eye-ball paints on the beginnings of its nerve-fibres to the brain. But that little picture sets up an electrical storm. And that electrical storm so set up is one which affects a whole population of brain-cells. Electrical charges having in themselves not the faintest elements of the visual—having, for instance, nothing of 'distance', 'right-side-upness', nor 'vertical', nor 'horizontal', nor 'colour', nor 'brightness', nor 'shadow', nor 'roundness', nor 'squareness', nor 'contour', nor 'transparency', nor 'opacity', nor 'near', nor 'far', nor visual anything—yet conjure up all these. A shower of little electrical leaks conjures up for me, when I look, the landscape; the castle on the height, or, when I look at him approaching, my friend's face, and how distant he is from me they tell me. Taking their word for it, I go forward and my other senses confirm that he is there.

A wonder of wonders which is a commonplace we take for granted. It is a case of 'the world is too much with us'; too banal to wonder at. Those other things we paused over, the building and shaping of the eye-ball, and the establishing of its nerve connections with the right points of the brain, all those other things and the rest pertaining to them we called in chemistry and physics to explain to us. And they did so, with promise of more help to come.

But this last, not the eye, but the 'seeing' by the brain behind the eye? Physics and chemistry there are silent to our every question. All they say to us is that the brain is theirs, that without the brain which is theirs the seeing is not. But as to how? They vouchsafe us not a word. Their negation goes further—they assure us it is no concern of theirs at all. "That the eye is necessary to sight seems to me the notion of one immersed in matter." Such was this disparation to J. S. Mill.

But to return to the making of the eye. It seems clear that here is a subject which might well test the point of view say of Lucretius on the one hand, and our sixteenth-century physician, Fernel, on the other. Knowledge of much of its detail is, of course, new since either of them. The marvel of it has not grown less for that. The impression of perfection and endless resource which it leaves as a creative exploit, is occasionally broken by disconcerting incidents; something goes wrong. Fernel would not ask, but Omar Khayyám we remember asked, "And did the hand then of the Potter shake?" Thus, in the matter of the optic cup. Just within the lip of it, which holds the lens, the rim of the cup thins and becomes the circular iris which gives the eye what we call its colour, hazel, brown, grey, blue as the case may be. The circle of it is not at first complete because the cup is fissured at one place so that in its circular rim there is a gap. Later the groove closes and the iris becomes a perfect ring. But in some instances it does not so close; there is a gap in the iris extending from the pupil as a notch. The defect does not occur at random. It runs in families. In that great multitudinous creative dance which we traced, if things are to go right for the finale, the evolutions of the part-figures must keep step, or certain partners may arrive late at certain places for partners who will then already have moved on. A point we have to note is that in this great dance once a mistake made there is no subsequent recovery. Moreover, the individual dancers seem blind themselves to any mistake which may have happened. Again, in the building of the nervous system where certain nerve-fibres have to grow far to join particular others also converging to a certain spot, their punctuality in keeping appointments counts for much. The time-keeping in fact is not exact; in consequence no two individuals of us have a make-up of spinal nerve-roots quite alike. This gives the surgeon trouble if he has to operate on us. That misfits of this kind happen seems to suggest a fallible mechanism at work rather than a supreme ideal in process of heavenly accomplishment.

Success of the production of the infant creature is judged far more subtly by the truth of the working of the resultant life than by any test which inspection by the eye or microscope imposes. For instance there is its endowment with colour-sense.

That is, we know, sometimes defective. There are born those unable to distinguish as do most of us between red and green. The eye and retina, and everything is normal in them to the minutest microscopic examination; nor is any part of the brain, visual or other, recognizably defective. The defect haunts particular family stocks. It is related to sex; it goes with maleness. To the geneticist that is a clue. Sex is a feature the development of which in the individual is traceable to a definite visible element in the egg. That element contains, along with potential sex, certain other 'characters' which are called 'sex-linked' because linked with the gene of sex. Each 'character' has its gene. Colour-vision is a 'character' related to a gene. Normality in this respect may be wanting in one parent. The defect lies in a gene which is of those linked with sex. In males a chromosome y, from the father, partnering chromosome x from the mother, is small. It lacks duplicates of some genes in x, and so may not cover defect in x. But in females a second x-chromosome, from the father, may cover such defect. The mystery which at first seemed to deepen with knowledge of the strange preference for one sex, on further knowledge tends to clear. It resolves itself into mechanism. Chemical mechanism, for the gene seems to be a catalyst of the chemical nature of a protein.

It is less than a generation since Edouard Gley, at the end of an address inaugurating the academic year in Paris, remarked that 'Determinism' in the shape of Physics and Chemistry was, as a means of explanation, dominating Biology more and more. But, he added, one biological domain there is which it will never take over, the growth of the egg into a child. Time already belies his prediction.

A mechanistic factor seems to lie in the influence of one part of the growing embryo upon another part. We saw an instance in the eye-ball. A bud from the embryo-brain is the beginning of the eye. The skin over that bud dips down to meet it, and becomes the lens of the eye. Brain and skin, although separate, conspire and meet to build an eye. In the young tadpole the bud from the brain may be transplanted to a point distant from where the eye should be. At the new place the skin dips down to meet it there to form a lens for the eye which should not be there. At that new place the skin does just as would the skin of the right place. Again, if the skin from over the brain's eye-bud be replaced by skin from elsewhere, this latter skin, although not the right skin, dips down towards the eye-bud and forms a lens. Evidently an influence from the brain-bud extends to parts around. The biochemist tells us his next step will be to trace that influence to a particular chemical source. He speaks securely for he has done the like before.

Again, if a piece of that part of the embryo which is to be the main nerve-cord be removed, and its place given to other skin and taken from a region not destined to be nerve-cord at all, the new graft not originally destined to be nerve-cord becomes nerve-cord. The embryo at this stage seems pervaded by some general invisible plan which compels each of its localities, whatever the provenance of the material there, to become what is demanded there as part of that invisible but immanent plan. Later on, the trend in the local part to be what it set out to be becomes too strong to permit change. Then, the rudiment beginning to be a limb, will be a limb whatever happens, and wherever the experimenter puts it.

There is a time when a certain restricted bit of the embryo, in what will be the embryo's back, has a curious power, as so-called 'organizer'. If it be transplanted to some part of another embryo, it there sets going and seems to direct a wholesale scheme of development, almost tantamount to starting a new embryo. Something like this at times happens naturally. There are two kinds of twins. One kind is traceable to the fertilizing of two eggs. The twins then are not more like each other than are other children of the same parentage. In the other kind of twins both come from one and the same fertilized egg. What happens there is that the egg implanting itself as usual and drawing nutriment from the mother, its primordial cell mass, probably at first as usual just one embryonic rudiment, then proceeds to start a second embryo. These twins are always puzzlingly alike. The Canadian quintuplets are of this kind. In their case the same fertilized egg produced an accessory embryo not once but four times over. The 'organizer' explains how this might have happened. And the 'organizer' itself is receiving explanation as a chemical action, or rather as a set of chemical actions. A chemical extract has been obtained from it which shows organizing power. It is a substance of the nature of a sterol and has been isolated. Thus the organizing property of the 'organizer' is found to lie within the scope of chemistry.

This has collateral interest. The sterol is chemically akin to compounds now known to evoke cancerous growth. Its identification with this chemical group brings therefore the organization of the embryo into the same chemical picture as other growth, and that disease of growth, 'rickets'. Also with the chemical control of the menstrual cycle, and finally with the start and growth of cancer, misgrowth. There seems an underlying relation between them all, in nature chemical. As our sixteenth-century physician would say, that bids fair for medicine. A critic of Edouard Gley, of determinist pattern, would add, all looks like mechanism.

Our brief glimpse must not let us suppose that when the embryonic phase of life is over, this power of the parts of the body to 'become' reaches its goal and ceases. Suppose a wound sever a nerve of my arm. The fibres of the nerve die down for their whole length between the point of severance and the muscles or skin they go to. The skin there has lost sensation, in my muscles there I have lost 'my power'. But at once after the injury the nerve-fibres start to regrow from their cut points, even far up the arm. For three score years and more these, my nerve-fibres, have given no sign of growth. Yet after this wound each fibre, whether motor or sensory, would start again to grow stretching out toward its old goal in muscle or skin. There would be difficulties in its way. A multitude of non-nervous cells busy on repair within the wound might spin scar-tissue across the path. Between these alien cells the regenerating nerve-fibre would thread a tortuous way, never uniting with any of them. This obstruction might take many days or weeks to traverse. Once through it the young nerve-fibre would press on and reach a region where the sheath-cells of the old dead fibres would lie altered beyond recognition. But they and the new growing nerve-fibre would, as it were, recognize each other. Tunnelling along endless chains of them, it would arrive finally, after weeks or months, at the wasted muscle-fibres which were its goal. These too it would, as it were, recognize forthwith. With them it would unite at once. It would pierce their covering membranes. It would re-establish with them junctions of characteristic pattern resembling the original which had died weeks or months before. Nor would one nerve-fibre of all the thousands join a muscle-fibre which another nerve-fibre had already begun to repair. When all the repair was done the nerve's growth would cease. The wasted muscle would recover; in my skin which had become insensitive, sensation would return.

Nerve-regeneration seems a return to the original phase of growth. Pieces of adult tissue which have long ceased growing, when removed from the body to artificial nutrient fluid, begin to grow. Epithelium, which in the body is not growing when thus removed, will then start growing. The cells then lose their adult specialization. In nerve-regeneration the sheath-cells and, to some extent, the muscle-cells which have lost their nerves lose likewise their specialized form. They regain it only when touch with the nerve-cell has been re-established. Mutual touch between cells decides much in their individual shaping and destiny. The severance of a nerve-fibre means loss of this touch. The severance, by rupturing that connection, removes something which restrains cell-growth and maintains cell-specialism.

There are further mysteries still. As we saw, a scrap of the heart of the embryo-chick put into a glass tube thirty years ago, protected from germs and fed, is growing still. Had it remained in its chick it would have died years since. In these instances of the behaviour of the body which we have been sampling—they are samples taken from thousands—two questions among many rise perhaps urgently for us here. Whence comes the means and whence the prevision? The eye prepared in darkness for seeing in the daylit world. The ear prepared in water for hearing in air. In the repair of the cut nerve, provision against a contingent accident possible enough which yet may never happen. Or, to take one sample more. The body practically never can suffer a wound without the tearing of some blood-vessels. That means loss of blood; and severe loss of blood can be fatal. The loss would always be severe and probably fatal if the bleeding did not stop. It would not stop, did not the blood solidify when and where and as it escapes. The blood clots and seals the point of escape. This solidifying is the work of an enzyme. The enzyme is ultimately traceable to a source in a particular gene. Some few of us are born deficient in this innate styptic. It is a defect which runs in families. It is sex-linked and that helps the geneticist to trace its gene to a particular element. Now, to do that is to trace it, and the normality it departs from, to chemistry.

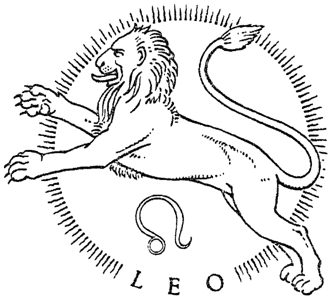
Evidently the physics and chemistry of the cell can do much. Can they account for all that the cell does? That is, in short, can they account for life? Chemistry and physics account for so much which the cell does, and for so much to which years ago physical science could at that time offer no clue, that it is justifiable to suppose that the still unexplained residue of the cell's behaviour will prove resoluble by chemistry and physics.

Does the wonder then lapse of which we spoke at the outset? The cell's doings are affairs merely in routine conformity with ascertained ways of 'energy'. To apply the term *tour de force*, as at the opening I ventured to apply it, to any of these phenomena is out of place. Nor can we regard the 'human' as more wonderful than any of the rest. But a wonder is there still. True, we can understand Keats' sighing against science, "there was an awful rainbow once in heaven!" Yet he was "to find", as has been written of him, "material in the scientific view of the world for the highest achievements of poetry". Could we foretell the rose-bud from its chemistry, would that make its beauty less? Does such knowledge impair the beauty of the world? Surely the reverse, for we then know that such as the rose-bud are neither accident nor miracle. The wonder is there still. It rests on different ground. Nature is not made less wonderful because her rule of working begins to be intelligible. If it be a question of wonder, rather the more wonderful.

In this becoming of an individual as we have glanced at it, what of the old controversy about the essence of life? There is on the one hand our sixteenth-century physician-philosopher with his invocation of an immaterial principle to account for it, and on the other hand, not the ancient materialism of mere *a priori* speculation but the embryology of today. This last is a body of systematized facts drawn from controlled observation and analysis, and on that basis marshalled and harmonized to a working conception. It is in short a likelihood grounded in fact and established by reason. Its methods are physics and chemistry. We would ask of it, does it find itself adequate to all the phenomena it meets in examining this development of the egg into the child? Is it adequate to describe this 'life'? Its answer is that it finds itself to be so. It says that it has no need, and therefore no room, for Fernel's 'essence' or 'principle' of life. Its answer does not mean that it is ready to account for every detail in the becoming of the child. Where there are millions of details there has not been time for that. But sampling key-instances and solving them it is left with the conviction that the problem before it, the problem of the how of this unfolding individual life, is one which it is solving and is competent to solve throughout. It repeats that its methods are 'chemistry and physics'. The concrete life in its maintenance was, we saw, a question of chemistry and physics, and the 'becoming' of its organism is so no less. Embryology today tells us that chemistry and physics are the solution of its problem.

Contrasted with this account furnished by scientific embryology, with its observations, and measurements, and facts, its agents and its technique, that furnished by our sixteenth-century Fernel presents a simplicity reminding us somewhat of a fairy-story. Yet in one respect it is a fuller account than is the other. "Our task", he says, "now that we have dealt with the excellent structure of the body, cannot stop there, because a man is a body and a mind together."* The message is in so far something like one of Professor Whitehead's to-day. Fernel's account of the becoming of the individual included the becoming of the finite mind. But in the account rendered by our chemico-physical embryology of to-day the latter's becoming might not be for any reference to it which is made. That is understandable as methodology; but it is usage to-day quite outside methodology. When we are told that the modern chemist and physicist cannot get on without the hypothesis that matter explains everything, a position is reached akin to that of initiation into a faith. A rigid attitude of mind is taken as an orientation necessary for progress in knowledge. Is there anything different between that and the efficacy of the spiritual exercises of St Ignatius as introductory to mystic convictions expected to follow? What either expedient may possibly gain in intensity of insight is surely at disproportionately greater cost to breadth of judgment.

* *Physiol.* v, 1.



V

EARTH'S RESHUFFLING

. . . the course of nature . . . seems delighted with transmutations.

NEWTON, Query 30, *Opticks.*

The early lilies became part of this child,
And grass, and white and red morning-glories, and white and red clover, and the song of the phoebe-bird,
And the fish suspending themselves so curiously below there—and the beautiful curious liquid,
And the water-plants with their graceful flat heads—all became part of him.

WALT WHITMAN, *Assimilation.*

I deem I was not made for heaven or hell
But simply for the Earth.

W. MORRIS, *Bellerophon at Argos.*

V

THERE are words which some turn in the history of thought suddenly overwhelms with a large special meaning. Such a one is evolution. We might prefer to qualify it as 'biological evolution', were it not that, scientifically speaking, the distinction between 'living' and 'lifeless' seems somewhat strained. The special connotation attaching to evolution implies that types of living things have, like human affairs, a history which can be traced, and that when traced their history bears witness to a progressive change whereby what they are is different from what they were. New types, the expression runs, have been 'evolved'. In the course of their history, in many cases more complex types have evolved from less complex. And that aspect of evolution is of particular interest to ourselves because we ourselves seem to be among its instances. We seem an outstanding example of it.

I would be clear as to what we may mean by 'new' evolving from 'old'. 'New' signifies here no more than a fresh arrangement, a reconstruction, a novel combination, of parts, the parts themselves not other than those existent before. New therefore in the sense in which we speak of new machinery which is but modified older. The new machinery is evolved from the old, in the sense that the old has been a starting point for the new, either in design in the hands of the designer or in material in the hands of the craftsman. This is not the same scope as M. Bergson gives his 'évolution créatrice'. There, as is usual where 'creation' is spoken of, he means that something new springs into being *de novo*.

Biotic evolution, to use that term, is constantly producing new combinations of old parts; the parts themselves being often very elementary ones—e.g. electrons, protons and their primary combinations, their atoms. From these certain new molecules have appeared.

When the reshuffling is so radical as that, its results can be far-reaching. Evolution does reshuffle as radically as that. Molecules make their appearance of kinds which were not before. We may suppose there has been no advent of a new type of living thing without the production of some chemical compound the exact like of which had not existed previously, at least so far as concerns Earth. The evolution of a series of types of life includes the invention, so to say, of many molecules of pattern fresh to our planet. Evolution has in its time produced a vast array of new forms of life and in virtue of that an even vaster array of chemical stuffs. They lay, so to say, latent as possibilities of the planet but actuality had never called them forth. They are an instance on a huge scale of a new 'becoming'. A becoming which held within it the secret of life, for the progressive evolution of successive living types was its accompaniment. A book, a great book, waits I think still to be written on the chemistry of evolution. The material for it already fills volumes. But I would feel that it still wants telling as one connected story. I am not competent to put it before you even in outline. Almost every one of the great classes of chemical entities which we, quoting Dr Needham, cited as together essential for the organized system of living substance was a something unknown to earth before life came. Evolution has called up a new chemistry. Yet, fundamental to remember is that it is still the old chemistry, still the same chemistry as was in essence before life came. It shows no *fundamental* departure, though it is a rich extension of endless variety within certain limits. The old principles comprise it, the old subatomic elements supply it, a certain set of the pre-existing atoms furnishes all the atoms it requires.

It is in fine after all a reshuffling. That may remove it from the utterly extraordinary. On a smaller scale man himself today does the same thing; wittingly and of set purpose and knowing how to set about it. Does it seem strange that an unreasoning planet, without set purpose and not knowing how to set about it has done this thing to an extent surpassingly more than man has? It is to be remembered that Earth's periods of time have been of a different order from man's, and her scale of operations of a different order, and that man's cunning in this respect dates but from yesterday. Yet, we agree, it does seem strange.

It is perhaps more surprising that it should have dawned upon the human mind only so latterly that his planet was a place of freshly arising shapes and powers of life. There was evidence of it in all directions round him but he had somehow failed to see it. It now gives him a new conception of his planet and of his place there. The constant intrusion of such novelty into this world had escaped the notice of his forbears of antiquity. It had not escaped them that the world shows changes. But its changes they had glimpsed rather as recurrent cycles of change. A progressive change which could be shown to have produced the novel and then scrapped it, and produced the more novel, and then scrapped that, and was still going on in like fashion generating and trying-out the novel cumulatively, without halting for a moment, millennium after millennium, must, he now begins to surmise, be doing something which 'leads somewhere'. That was a conception antiquity had not reached. Their factual knowledge was not adequate to it.

It is strange but true that one among the animals should have been led to fancy itself so different from the rest as actually to forget that it was an animal. Of new biological stand-points which last century gave us one most fruitful has been that of man as one of the animals. The thought is after all merely a return to the common-sense of Aristotle. But last century documented it with fresh facts. It "has had an enormous effect in improving our understanding of the world".*

Thinking the thoughts that man now does, there occurs to him that at some not too distant future he, or some form of life which succeeds his, will compass chemical syntheses of substances which in ordinary parlance 'live'. He already constructs many of the substances which Earth has constructed as parts of concrete life. He does not however forget that his new knowledge which he calls chemistry, from the black art of Egypt, discounts his quest by saying it distinguishes no such thing as life. It is enough here that evolution by rearranging old parts is constructing new harmonies, chemical and biological. It is composing new melodies from some of the same old notes.

We are set wondering where evolution began, that is, how low down in the scale of things. Lives have evolved from other lives. Was life itself evolved? Is there a gap between animate and inanimate such that evolution could not and cannot

* C. G. Darwin, Galton Lecture, *Eugenics Rev.* p. 17.

bridge? Philo we heard* judge that there was not. With the more conviction could he so view the whole panoply of Earth's surface in its every item—rock, wave, cloud, herb, tree, insect, fish, bird, brute and man—from start to finish and without exception, as offspring of the planet's side. Some, for instance Helmholtz, Arrhenius and others, have thought life's beginning on this planet must have been a seed drifted across space hitherward from who knows where. But life seems too narrowly terrestrial in its simplest characters to derive from any other origin than Earth's self.

The animate and the inanimate as we have seen are in their ultimate parts alike, and fundamentally so in the principle of their construction. Is then transition by intermediate steps from the latter to the former unthinkable? Not unthinkable. When we systematize, the animate falls unconstrainedly into series with the inanimate. The animate then becomes merely a special case within the more general. Analogously, the chemistry of the whole series of the carbon compounds taken within the chemical system is merely a special case within the more general. Is then the transition between the inanimate and the animate unthinkable? No: but not observed.

The history of the planet, we are told, says that only after a certain stage of its cooling could the chemistry of life obtain. It says that not so very long after that possibility arose, life did in fact appear. Put untechnically, times until then had been too violent for life's relatively unstable chemical systems to maintain themselves. Four of the very commonest of the atoms went mainly to the making of these new systems for which possibility had arisen. Dynamically balanced systems, with 'governor' systems locked into them to regulate them, and retrieve the balance when it leans dangerously far. Physics shows that where phases, for instance, liquid and solid and gaseous meet, special opportunities for interaction occur. Our planet offers such a place. What we call its surface is a great interface where phases solid, liquid and gaseous meet. They meet as rock and tide and air. At this interface many new systems could be formed and must have been. There it was that the new systems we are thinking of will have arisen at that

* *Vide supra*, ch. iii.

particular stage of earth's cooling. They were complex, delicate, and individually short-lived as against many of the old systems of the field around them. But we are tempted to look at these differences as differences of degree rather than of essence. These, inasmuch as they were 'living', would come under today's rubric biology, those others under physics. If we follow Professor Whitehead the distinction between biology and physics is that biology studies the more complicated organisms, physics the less complicated. Mr Monsarrat tells us the same thing. Do not at some point these merge with those? At some time was there not transition to the one from the other? May we not think that our planet's side, at that stage of its history which began our history, was a stage so set that physical organization merged into and passed over into, using the word in its current sense, biological? May we not think it a situation which allowed possibility of transition from inanimate to animate, and that the possible took place? The transition occurs today but only under contact with existing life, existing life which, acting like a ferment, catalyses dead systems into living. Apart from that particular case, this transition appears today to be irreversible. Easy enough from living systems to dead, but not the converse. Was it so always? Surely the very existence of life answers, no.

Once having started, the systems which live proceeded in numberless instances to become more complex. In that respect the difference between, in Whitehead's phrase, the physical organism and the biological organism, increased. This progressive complication was the work of evolution. Often the more complex evolved from the less complex. What does the progressive change to greater complexity, which often accompanies evolution, do for life? What does the complexity add? Does it bring anything wholly new?

It increases size. Life is taken out of the region of the microscopic. That is not unimportant. We are in a world of different sizes where size counts. Life enters a different region of the scale. The things it can and cannot do differ from those which it could and could not do when microscopic. But to enter a different scale is not of itself to be anything wholly new. The component units of the individual are more numerous. Each of those units being a tiny quasi-independent life, the multiplication of units allows higher specialization of different parts of a compound whole, though the whole still remains an integrated system, a unity. That is one aspect of the increasing complexity which evolution stands for. The individual has greater range of doing. Mere increase of the number of the constituent units need not of itself however carry far. There are examples where large numbers of unit-lives cohere and compose masses but, as regards ability to do, gain thereby nothing or little, because organization of the aggregate mass in fresh directions does not accompany their coherence. There is no further integration, no further 'individuation'. Organization with differentiation of component units for this and for that, and at the same time co-operation between them one with another so as to serve the unified composite life; that is the kind of complexity which evolution shows to be the more significant. It is an ampler integration. Does such integrated complexity, as we might call it, bring into being anything absolutely new? Does it create anything? Does it, besides extending the range and powers of life, introduce anything which simpler life has not? Is there anything more in man than in amoeba or paramaecium beyond amplification of powers of the latter? Anything different in kind? A new mode or category of life? Is the more complex something more than increase of complexity of a type of system already existent? We should hardly expect so. Yet it does seem to be so. The complexity introduces recognizable mind. It does so gradually, and nurses it into flower.

In turning to the facts of evolution as far as we observe and know them, we should wish a detachment of view not always easy to ensure; nor indeed, for some purposes, wanted. When we study an adventure which is largely the adventure of our own kin and ourselves, we are apt to take sides. In scientific appraisement it is well to try to forget any particular predilection, even man's. Not that we can forget it. But we may at least try to avoid some of what might be called our besetting 'anthropisms'. That is to say, egoism which can distort the picture we would see as it is.

We are thinking of the individual life, and life is always and has always been individual. There is here no question of a 'universal' because any attempt at definition of life must start out with the concept 'individual', otherwise it would not be life. In the early phases of life's existence on the earth, the living thing was in all instances, we may think, microscopic. Then in course of time, in the forms which interest us especially, it became larger, multicellular and much larger than microscopic. It emerged from the microscopic. But to say that is to put forth a somewhat sophisticated version. It will do for a headline, but is only a partial truth. In a sense we are still one-celled and microscopic.

Evolution tells us that the plants and animals of today are the growing-points of a genealogical tree; perhaps one single tree. Each generation in its turn has been the set of growing-points of that tree. Some of these growing points have in course of time come to produce more highly organized life than do others. The growing points producing highly organized growth trace back however along their stem to simpler prototypes. Their lineage converges as they do so. The whole genealogical tree traces back to some few relatively simple prototypes; it may be to a single one. Whether to one or to several it would seem that the type or types finally led to by the backward trail were originally in each instance microscopic.

In those branches of the lineal tree which bear the more complexly organized types of life, such as those of our own stock, the actual growing point has a cycle of growth. On its way to provide the next growing-point in succession to itself, it produces what is sometimes thought of as a vehicle to carry it, a nurse for the growing-point. This vehicle is a many-celled individual. "The hen is the egg's way of making another egg." The growing-point is microscopic, but the vehicle is not. The vehicle produced from the growing-point is a coherent family of cells, a multicellular unity, a corporate life. In our own case it is what we regard as the human individual. Figuratively, the genealogical tree entrusts its next successive growing-point to this corporate individual which is formed as a by-product from the previous growing-point. The organization of this individual is various in various branches of the tree. In some of them it forms the most complexly organized individuals which nature offers. But, however well organized, it is always a by-product in the meaning that, from the point of view of the growth of the tree it is just a vehicle for carrying and nursing the next successive growing-point of its particular twig. If we ask the purpose of the body and of all its organs, its heart, its lungs, its brain, it is for the purpose of housing there the sex-cell. Its organization into an integrated individual may make it so effective in doing various things, that other aims than that which, speaking for the tree, it was formed for, namely the continuance of the tree, may seem to itself the more important. It may be so with man who is one of these vehicles. As a growing-point of the tree itself, he is still microscopic.

In the vast majority of instances, remaining microscopic throughout a relatively brief life, he or she dies never becoming any other than a single microscopic cell. The chance of fertilization has been denied him or her. For instance, as a futile spermatozoon he is one of the vast army which does not survive. Such sacrifice is the rule; fertilization is the exception. Fertilization is his sole means toward becoming a growing-point not merely potential but actual. When, as exceptionally, he becomes an actual growing-point he is still one single cell and for a brief time remains so. But in his next or somatic and multicellular phase some of his cells may live individually for even a 100 years or more; in the centenarian some nerve-cells are centenarian.

As potential growing-point and as initial growing-point he is for the time being a single cell. It is by that single-celled phase of his existence he is connected with the tree, and traces with his prehuman forbears back along it for, say, a 100 million years. All that time, with every generation, he cast off a vehicle. Quite recently that vehicle has come to take the form of man, or better said, since our being is 'doing', has come to do as an individual what it is human to do. Among other doings it has come to think, as we say, using 'reason'. The time may come when, observing itself to be essentially only a vehicle for the next successive growing-point, this individual may reason that it is not worth while to be. On the other hand it may, considering what it represents in life, assess its rôle as a transcendent privilege, which the cumulative vicissitudes of 100 million years have, somehow, crowned it with. It may glory in the acceptance and fulfilment of a rôle fraught with capacity for progress.

In man therefore, as in many other of the lives which under evolution have come to be, the complete individual-life presents two phases, one unicellular and microscopic, the other the multicellular man. The one phase succeeds the other, it matters not in which sequence we take them. The phases alternate. They are links in a chain. The microscopic phase is shorter-lived. A growing-point, but at first only a potential one. A potential bud with which, that it may bud actually, another potential bud must conjoin. And these two, we are thinking of man and his kind, must come from two individuals, sexually different but of the same species.

We can understand a little from this how the tree while it grew kept each branch true in general pattern to that branch and yet not exactly mere repetition. Each particular life starts, so to say, doubly anchored in species, but with swinging-room between two individuals. The two potential growing-points represent the same specific type but two individual versions of it. The hereditary disposition to produce like kind is strengthened as regards the species but as regards individual likeness must be a compromise between two different specimens. A certain degree of fresh departure is assured. The multicellular phase which follows on the unicellular phase thus presents an individual unique of its kind. Professor Whitehead inclines to embrace under the term organism the atomic and molecular aggregate of physics as well as the organisms of biology. If we do that, the inference rises that there has come with life an enhanced individuality of organisms, and that that is increasingly so in the forms where life evolves complexity. Individuality would seem, so to say, to be through complexity an *aim of life*. Yet we must not forget that physics is less able to reach its individuals; it deals with them in swarms and populations rather than with any individual *per se*.

As to the power of certain cells to produce a coherent progeny which proceeds to organize as a collective unity, a multicellular individual, how that propensity arose is, I fancy, little known. We accept the fact. Nor do we know closely when first it came to be. It goes back very far in the geological record of life. Be that as it may and however it came about, it was an event of fateful trend. It put into the hand of evolution, we may think, the most promising material and conditions which evolution ever had. Evolution proceeded to make with it lives of plant-kind ranging from the saprophytic mould up to the forest tree, of animal-kind from the worm and less upwards away to man.

There is a certain stability in Nature—a 'toryism' if you will —which makes old ways die hard. Thus with the human egg. Eggs, speaking in general, are of two types, the small type and the large type. The former, the sea urchin's as instance, have scanty food reserves (yolk) diffusely scattered and not stored in one lump. Such an egg in its growth segments right across, the whole of the egg taking part in the embryo. The large type of egg, the hen's for instance, is a million times larger. Its yolk is immense, and that part of the egg which makes the embryo is restricted to a tiny 'germinal disc' discrete from the yolk. Now the human egg is a very small one and its yolk is negligible, and like a yolk-free egg the whole egg segments up. Yet for all that it belongs ancestrally to the big-egg type; and it shows very clearly that it does so. It segments right up but only a little part goes actually to making the embryo. The rest forms accessory structures such as a 'big' egg does, as if for the embryo to draw on a great yolk-store. The key to this behaviour is ancestry. The mammals—ourselves for instance—belong by ancestry to the big-egg type. We derive from the reptiles. The reptiles laid 'big' eggs and their doing so was a key-feature in their history. The big reptilian egg provided its embryo with a bath which, immersing it, did interim duty for the sea. It was one of the devices which emancipated the reptile from life's universal bondage to the sea. The reptile evaded the sea and took to land. Its migration proved an enormous success. The reptiles peopled the land. Exploiting the land they became in their time the living masters of our planet's side. They swam, they flew, and they walked the earth. Some of their kind attained gigantic size; the ooze quaked with their tread. They had their era and then, unaccountably, declined. But some of their smaller fry had been providing themselves against vicissitudes, not with armoured hides and immense thews but with a furry skin and milk-giving glands and an embryo which for its early period was parasitic on its mother. These aberrant reptiles avoided the perilous winter-sleep by intrinsically managing the body as a furnace. They seemed to know what

Lavoisier was to discover, that 'to breathe is to burn'. These early mammals like their reptile ancestry had 'big' eggs and laid them, as primitive Australian Echidna documents to us today. But in the mammals as they evolved the large egg dwindled, the yolk becoming less and less. The embryo drew more and more its direct nutriment from its mother. The egg nevertheless still retained its old ways of the luxurious big-egg type as if it had huge reserves of food-yolk to draw upon—only the reserve of nutriment it now turned to was the blood circulation of its mother. It now sucked in the approved big-egg fashion not yolk but its mother's juices through a placenta. The old habit of life was not departed from, not scrapped; it persisted, turned to account in a new way. It was like Pareto's description of traditional ceremonial in England, the old bottle but a new vintage.

Just as structure once established is slow to disappear so too is 'process'—the distinction between them is but artificial. On the Antarctic ice the penguin, since first it was a penguin, can never have seen a tree. It cannot fly. The wing is dwarfed to a little paddle. Under it the head cannot possibly be tucked away, the wing is far too small. Yet faithful to the habit of forbears thousands of years before, the penguin when it composes itself to sleep turns its head and puts the tip of the beak, it can no more, under its midget wing. The buttons on our coat-tails once attached a sword; but such conservatism is as nothing to the penguins' heredity. Yet Nature, often as she hugs the old, seems seldom or never to revert to a past once abandoned. The ocean whale might dream of bygone land-pastures sooner than its limb-rudiment, did it return to land, would ever be again the land-limb once it was. On the other hand for its limb to develop into something utterly different, would be no unlikelihood. What had been for millions of years during a watery existence our apparatus for breathing has now nothing to do with breathing but serves our hearing in the air. Evolution can scrap but not revive. Doubtless the geneticist can say if this is so, and if so, why. The huge beasts whose size and weight are thought to have been their ruin could, one might suppose, have been saved by return to their less cumbrous ancestral types. But no, they were scrapped and other types brought on.

Obstacles to life's adventure we might have supposed insuperable were overcome. One of those old difficulties was that life at its beginning had been wholly aquatic, though so long ago that the very saltness of the sea was then much less than now. There the lives in it, for instance those of our own primitive stock, multiplied, flourished, and evolved. Later this life invaded the land. Some of our own early stock took part in that invasion. Life, as chemistry, is so to say a dynamic 'steady-state'. The moving equilibrium of the cells' life in our early stock was almost literally an energy-eddy in the sea. The water of the sea conditioned it. Its energy-exchanges were based upon the sea. How if cut off from the sea could such a life exist? The Canadian biologist, Archibald Macallum, gave a reading of this riddle. The salts dissolved in our blood today commemorate it, in kind and in concentration. They are those of the ocean of that long past geological epoch. Already in that sea the vertebrate creature, with many of its cells buried in the body's bulk, away from actual touch with the seawater, had evolved a system of branching tubes and a muscular pump, the heart, bringing to each buried cell a blood of salinity similar to that of the archaic sea, a substitute for that seawater in which its cells had first arisen. In this way the cells though buried away from actual contact with the sea still effectively retained their old habitat, to which their ways of life were adapted. The cell-mass forming the individual manufactured an internal medium, so to say, to substitute the sea. When it left the sea altogether for its Odyssey on and over land, it had but to carry that habit of manufacture with it. It has done so. With that it has crossed mountain ranges and desert sands carrying its own medium with it. It has invaded air as well as land. It runs, and flies, and walks erect. The water of ocean itself has changed from what in that old sea it was. It has changed with the washings of rivers into it for millions of years since then. But the blood, a dynamic equilibrium, has in respect to those salts remained steady. The poet sang, with more literal truth than perhaps he knew, invoking the sea, "the salt is lodged for ever in my blood".* Despite the vicissitudes of time the blood's salt still retains its likeness to the salt content of that archaic

* W. H. Davies.

ocean which our ancient ancestry forsook. That some of them did give up that old ocean allowed the possibility of our becoming what we are. What might have seemed to forbid at the very outset all approach to what we are, was ventured and overcome.

This strategy, by which life overcomes the obstacles of unfavourable environment, by manufacturing a piece of environment suited to itself and carrying it about with it, Claude Bernard was the first to detect as a physiological principle in the adaptation of the organism. Sir Joseph Barcroft has examined it anew, and has shown that it applies particularly to the maintaining, despite untoward circumstances, constancy of conditions for the brain. It is part of the basis on which we can rest our claim to be the most successful animal of the present period. An index of our success is our ability to dominate the external environment, and live efficiently under the stress of various adverse surrounds. That the human life conserves as it does through wide vicissitudes, climatic, etc. the normal activities of its mind, despite such threats (Barcroft), is an example of the polity of life as shaped in evolution.

The life of the cell is a moving equilibrium of a kind to which oxygen stands in special relation. An old phrase tells us that 'oxygen winds up the vital clock'. That clock needs continual rewinding. There is in the cell no large reserve or store of available oxygen. There is oxygen put away, but the continual need is for oxygen as cash. The free cell's surface, e.g. amoeba, is actually bathed by such oxygen as is in the field around it. The oxygen it needs lies at its door. It breathes it. But not so the cells when aggregated into the mass of a many-celled individual. Then some of them live many thousand cell widths removed from the nearest field-oxygen of the surround. Yet each and every cell requires supply from the field-oxygen, and also to rid itself of its own waste by casting this latter into the surround again. In the complex individual the field outside is quite remote from the great mass of its internal cell-lives. Evolution when it produced the many-celled individual had to meet this difficulty.

There is a process, so characteristic an accompaniment of life, as to have been even from primitive times accepted as life's veriest symbol: the drawing of breath. That process has given picturesque words and phrases which in all languages stand for life: 'anima', 'spirit', 'breath of life' and so on. Science, when in due course it came, had nothing in the main to add to that primitive inference about the rhythmic sipping of air as being close to the very heart of life. The body took a draught of something invisible which fed life's flame. Science when it came did but resay in its own words this which had long been thought. So too it confirmed that at the end of the individual life there was the return of something, beyond vision, to the air as life's concluding act. Science added detail, and some amplification. It taught in what way the taking of breath took part in a commerce between air and life. It showed how it was that the moving of the breast was of urgent import to every speck of which the body is composed. It found the process not magical but chemical. Are its symbolism and its pathos any the less for that? Does to add deeper knowledge detract from its assessment in human values? It would be a strange scheme of human values which could think so.

We were looking at enzymes, and at the key-position they seem to hold in the chemistry of life. In this eminently vital process 'breathing', enzymes play a key-rôle. They help us to it as chemistry. Our rhythmic breath renews the air in the lung. The blood, as it flows through, can thus take up oxygen and transport it thence to all the parts that want it; and all parts do want it with greater or less urgency; and with particular urgency the brain. In the brain the draft on it is always quick. The body's internal mass not having direct access to the air, the blood brings to it and into it the oxygen from the air and puts it within reach of the cells, for them to take or leave. The blood has no machinery compelling this factor of life, oxygen, into the cells. Its rôle is to offer to them a sufficiency whether they want more or whether they want less. This variability of need the blood stream, by broadening or quickening or both, meets with admirable flexibility. But each cell is arbiter of its own intake of oxygen. We remember that, microscopic though it is, each cell is a little self-centred life.

The secret of the cell's ability to take the oxygen offered it is the presence among the chemical systems of the cell of a special enzyme-system. Many substances in the body, that is to say within the cells, do not readily oxidize with molecular oxygen at the temperature which obtains in the body; they are dys-oxidizable. The respiratory enzyme in the cell can with molecular oxygen bring about rapid oxidation in the cell. There is present in a majority of cells a substance which throws in the spectroscope characteristic shadows; these shadows disappear on oxidation. In living cells watched with the spectroscope these shadows are seen disappearing and reappearing periodically (Keilin). Oxidation and deoxidation are going on. This is traceable to the respiratory enzyme. There is, it is said, only one part of the enzyme to 100 millions of the cell. None the less this 'breathing' is fundamental for the living of the cells. To interrupt it long ruins the cell beyond repair. Mercifully there are grades in the approach to that disaster. With the cells of the brain that kind of step is what the surgical anaesthetics are believed to proceed to. They hold up the breathing of the brain-cells and for the time being 'pain' is no more; still less intellect, memory, emotion. The mind is treated as a chemical process. And effectively so and as mercifully as effectively.

The catching up of oxygen into the spinning vortices of the cell is but one aspect of breathing. The other aspect is the relieving of the cell and the body of such energy-systems as are drained of all that is available in them for the body's use. These residues clog if they remain. In this relief the moving blood acts as transport and sweeps the débris toward the field outside. It sweeps it to the lung; that is to the gateway to the air. But as the stream runs past that gateway the stay of each arriving particle is short. There would not be time enough for due escape through the gate were not the expulsion specially speeded up. The blood provides an enzyme which hastens the hydrolysis of the carbonic acid (Roughton). The carbonic acid breaks up into water and carbon dioxide, and this latter goes through the gateway and is exhaled. The efficiency of the means is remarkable. We all enjoy its advantage, though we accept it as a matter of course. When we are physically active, as for instance when we run, a volume of blood eight times the whole of that within the body may race through the lungs each minute. Thus we can exert ourselves effectively to the degree we do.

A property of cells which comes into play in the developing embryo is that they unfold influences one on another which mere inspection of them would not guess, let alone discover. After the fertilized egg-cell's first division, each of the twin cells derived from it is the rudiment of one-half of the future creature (tadpole). But let the twin cells be separated without harming them and two whole tadpoles form. Each of the two cells produces then a whole creature instead of half a one. Evidently the twin cells in juxtaposition influence each other. Each restrains each so as to make a half-creature coherent with the twin half. Each left to itself tends to make a whole creature. The influence of each cell in contact is regulative of the other. Their growth is co-ordinated by reciprocal influence, mechanical and chemical. So similarly, nerve-cells have certain special points of contact one with another. At these points one influences another. The one excites the other to specific action or restrains the other from specific action. From this reaction the nervous system becomes possible and develops its integrative action establishing the individual.

Evolution entails reconstruction. The fin which swims reappears as the limb which walks, or the wing which flies. Not that what is a wing was ever a fin, but the rudiment now corresponding with a wing was potential once of a fin, not of a wing. In this transition the progress is often toward the more complex. It is as though a key to efficiency lay in complication. The human arm would seem, taken all in all, to be the most complex limb which evolution has produced; it is too we may think the most recently evolved limb. Perhaps it will lead to something more complex still. The human brain is the latest brain and it is the most complex. Increased nerve-management here seems to lead to more nerve-management still. New nerve is added to remanage old nerve. Fresh organization roofs over prior organization. Were it a business organization there would be criticism. Progress under evolution takes the direction of increased complexity of organization.

This is partly because progress may lie less in doing the few things better than in doing a multiplicity of things adequately. Thus J. Z. Young, writing of the nervous system, points to the greater complication of the honey-bee than of the worm. "Both can walk and eat, and the worm can swim and in some cases secrete a tube, but the bee can fly and collect nectar and pollen and make combs and stock them with honey, clean its limbs, dance to communicate with its fellows, warm or cool its hive, and sting an enemy." When a single specialization becomes highly effective for its purpose, it tends to become so inextricably entangled in the circumstances of a particular place and time, that it can never be disentangled. That is, evolution can forget that places and times change, and that the surround is always becoming another surround. A specialization outlives its use. It can become a fatal encumbrance. The more general has to be returned to, as a starting-point for fresh departure. That is less difficult with a complexity which means diversity of doing.

The planet as it changes is continually putting an end to types which it has made. It is continually scrapping old patterns which have served their day. Types which under a changed surrounding no longer sufficiently fit. It does not destroy them so much as lets them lapse. They are faults which eradicate themselves by being fatal; they amount to suicide. The natural history of Jean Fernel's time did not know this aspect of nature. Fossils gave the first hints of it. The mid-Victorian invocation to Darwinism, a decade before the 'Origin', arraigning Nature, urged against her that

> From scarped cliff and quarried stone
> She cries a thousand types are gone;
> I care for nothing. All shall go!

And Nature destroys not only her old life-patterns but her new ones too. If by a mutation is meant inborn difference from the parent which starts so to say wilfully and perpetuates itself, such occurrences are frequent enough. Some cannot perpetuate themselves because the individual never ripens. There is a lethal mutation of the rat where death ensues from an anomaly of the cartilage, long before maturity.* In the series of breeding experiments on the fruit-fly *Drosophila*, carried out over a number of years, more than 300 different mutations have arisen. Many of these bring about the early death of the individual. They are modifications of pattern which prove unworkable,

* H. B. Fell and H. Gruneberg, *Proc. Roy. Soc.* B, cxxvii, 257.

handicaps against the creature's living sufficiently heavy to preclude the individual's completed existence. They are misadventures in the field of new design. Such are scrapped before they go any further. Wild Nature would be a harder school still for 'freak' designs. What chance of living would some of the kinds of dog seen in our dog-shows have if born in wild Nature? Nature would weed such out of its stock almost at their start, were it not for man's intervention. In the remodelling of her stock Nature therefore lets some models lapse at once, while making and encouraging others.

And what shall we regard as progress? The naturalist is, as we know, accustomed when dealing with living things to speak of some forms of life as 'higher' some as 'lower'. It is a custom which extends far outside the naturalist. Indeed the naturalist is becoming more chary in his use of it than are the rest of us. He feels probably more than most of us one successful form of life is just as 'right' as another. To employ 'higher' and 'lower' seems in a manner to assume for ourselves the position of a judge as to what is best in this great universe. Our excuse may be that we are out to try to understand, and this appraisement is part of our attempt at understanding.

Setting aside the question of 'values' the bare facts as far as we know them show an array of concrete lives much more than myriad-fold in type. They maintain themselves as such although individually possessed of but a short term of being, and although beset by circumstances many of which tend to their destruction. Each is in equilibrium for the time being with its surround. But it is a labile system. Its very weakness as a chemical composite is its strength biologically, its advantage for the uses of life. It trembles like an unimaginably sensitive spring, and its trembling is sympathetic with certain specific vibrations. But violence easily overwhelms it altogether. Judging by this frailty of the living systems which we know today we may imagine life at the beginning a hazardous and oft frustrated adventure. Those earliest 'living' systems would be local products of the spot developed from what was there. Perhaps today it would be a matter of discussion whether to call them alive or not. But once established as a beginning 'life' has been extending its habitat ever since. Spreading in area, height, and depth, over the planet's side. It fits wherever we find it. Its fiercest competition commonly has been with other life. There are those forms of life which are termed 'parasitic'. The parasite lives on the body of some other life which is its host. In some types of parasite the circumscribed environment within a part of its host provides all needs and is all the parasite is adapted to. Its food being prepared for it by its host, all but its absorbent organs go. Apart from them it becomes a simple bag of genital products for reproduction of its kind. In its way it is a marvel of fitness for the existence it leads, and for reproducing its generations. Compared with forms of life which employ powers of locomotion which range continents or oceans, and finesse of behaviour which may outdo the utmost human ingenuity, the term 'higher' in the latter case establishes its convenience by logical right. If we ask a test for which among living forms are 'higher', range of dominance of the environment is one of the features to which the term 'higher' can be accorded. Since mind is one of the great keys to dominance of the environment, 'higher' in that sense in biology is almost graded by degree of mind. At the present time no range of domination of life's environment is so great as that of man. He is as regards conquest of his surround the most successful of all living forms. On that ground we can acclaim him the 'highest' of all living forms.

Now that the production of new forms of life can be looked on as a manifestation of the working of purely natural processes judgment stands freer in respect to it. We argue from it neither prescience nor regard for what in relation to human behaviour we call 'values'. It is well none the less to compare it with human standards of doing. Such comparison seems demanded. Uncritical admiration of Nature, whether inanimate or animate, has to be replaced by truer aesthetic and ethical evaluation. As to the former, much as has been written about Evolution, the aesthetic aspect of its products has as yet I think been barely touched on. That some relations in Nature and some concrete things in Nature have aesthetic appeal affording unsurpassable delight to man is no less certain than that some others seem to him unsurpassedly hateful. In living Nature what we were noticing was that, from the point of view of success and fitness, it is the complicated which seems to be Nature's climax of rightness. The simple is at a discount. Whereas in aesthetics the simple may, I imagine, constitute the very climax of admirable achievement.

In some ways, it is as though evolution said, "Other forces can destroy; in so doing they clear my way. But I build, and I go on building." Evolution is a corollary to organic growth; the inorganic does not grow and does not exhibit evolution. We have heard that Nature thinks in mathematics or in geometry. Being what she is we may suppose her not more of one calling than another, seeing that she is all. But if we choose, looking around us terrestrially, to indulge our fancy and to think of her as excelling in some one way it seems, on this planet, nowhere more evident than in chemistry. Of course, this may merely say "Man is beginning to know some chemistry". The subvisible structure of the living things which are evolution's material consists mainly of molecules of great complexity and size. Most of these are themselves products of evolution of life. That is, the very blocks with which evolution now builds it has largely itself evolved. Amending the term 'block', which is too static, let us remember the living edifice is strangely watery. We think with surprise of ourselves as 80 % water. It reminds us that the water in this evolving building is a field of action, an arena for the play of energy, more than an arena, a means and medium swarming with electrical charges; the water is no mere static cement but a busy scene, the market place of a chaffering population.

Among the acting systems which shape and dominate this field none are more important than are the proteins. These, even among the larger molecules, are giants. Each comprises a complex assembly of smaller but still considerable chemical groups. The proteins are aggregates characteristic of and seemingly essential to life. No concrete life commonly accepted as life is without them. Protein kinds are hugely numerous. They form an immense chemical race. Moreover the theory of their type of construction indicates that in almost inexpressible numbers more varieties of them could exist than have been found.

Their upbuilding, down-pulling, and modification by reconstruction form a large share of the business of the living cell, in other words, of the business of life. We may ask how, broadly taken, does the cell do this. It would seem mainly by those transferrers of charged energy, catalysts. The changes of molecular constitution, reassortment of atoms, with concomitant redispositions of energy, seem to be worked step by step by catalysts, enzymes. The process of constructing a complex protein can be summarized perhaps as a sequence of many steps at each of which a simpler but yet complex state is by specific enzymes turned into one still more complex. It may be that the product itself carries within itself ability to catalyse its own growth further. The chain of steps can go on, until the protein formed is one which has not the specific enzyme for building any higher. The synthesis of the proteins, their composings and transformations, seems the work of specific protein-constructing enzymes. And the enzymes themselves appear to be proteins. It is a case of one part of the cell, one constituent of the cell, acting on another; if you will, one charged system in the cell acting on another also in the cell. We are reminded of Aristotle's "Part acts on part, as in an automaton"; and as so often in principle he was right. Matter working itself. Our Jean Fernel would add, under incorporeal direction.

An enzyme is a potent means to an end, but each particular end requires its particular enzyme. The chemistry of the living body were it not for enzymes would need conditions of heat and pressure and movement of violence such as would destroy the living stuff. The enzyme is a specialized donator and acceptor of energy. It can be likened to a special channel along which energy can pour. The enzyme itself is not consumed in the action it favours. It lends a hand. A tiny structure, it is a rocking bridge that transmits and retilts for more. But it must fit at both ends. In every cell the enzyme-system of the cell is essential to the cell's living, which is to say, enzymes are essential to the living of the whole body throughout its every speck.

The smallest separate life known, the smallest concrete life, would seem to be the virus-particle. It is so small that in some instances the microscope has never yet been able to descry it. The so-called electro-microscope which enlarges effectively about twelve times more may pick it up as a 'blot'. The virus-particle ranges about the extreme of what the microscope, even when flooded with specially fine-grained light, can see. It is a great deal smaller than the smallest cell. It passes through the pores of a filter which keeps back the tiniest bacteria. It is so small as to be not much larger than some of those giants of the subvisible within the cell, the protein-molecules. The virus-particle cannot therefore embrace within it a great number of large molecules. Its life must be in so far reduced to the simple and at the same time to the very special. Extreme simplicity and extreme specialization often go, as we were saying, with parasitism. The virus-particle is parasitic on other life. It lives by turning the protein of its host into its own protein. That is to say, minute and minimal as it is, it yet lives by enzymes; again suggesting that the enzyme is ubiquitous in life.

The cell was discovered some two and a half centuries ago. But not until last century was attention drawn to a 'little area', —so its first describer the botanist Robert Brown termed it—as constant feature inside every cell; a speck within a speck. This 'nucleus' is a nodal point in the cell's living. If the cell be torn into two parts, one containing the nucleus the other without it, that with the nucleus, even though much the smaller, still goes on living and repairs itself. The other without the nucleus dies and disintegrates. Whenever in the course of growth the cell multiplies, the nucleus divides and one half of it belongs to each of the daughter cells. The nucleus is seen to initiate the division. Again when two cells conjugate the coming together of the two nuclei seems the step most important in the whole process. The details of the nuclear union are facts fundamental for the studies of the geneticist. The nucleus is too the cell's nutritional nodal point and centre. Its influence extends through the field of the cell right out to the cell's surface. That may not seem far since cells are small, but in molecular distances it is so.

A unit integrated of subunits seems always to meet sooner rather than later an upper limit of dimension. The atom would seem to say so and the organic molecule would seem to say so. It is so with the cell. With the cell the explanation of the limit is broadly clear. The cell is an integrated system which depends on upkeep of currents of energy through it. The medium for the energy-exchange of the cell with the surround is the interface between the cell and the surround, in short, the cell-surface. The quantity of the energy-exchange is, other things equal, a function of the cell-volume. For a cell approximately spherical a size-limit is soon set, because the volume increases as the cube but the cell-surface for interchange only as the square. The cell lives so to say on its surface. A certain amount of cell must have a certain amount of surface, i.e. contact with the surround. A spherical cell if it become *large* possesses insufficient surface for the energy-exchange essential to its 'living'.

In some cases the cell, though microscopic in most directions, stretches in others to much greater than microscopic distances. It may be a thread even two feet in length, as in our nerves. Its end then is, microscopically speaking, immensely far from the nucleus, molecularly speaking astronomically distant. Yet, to cut off the thread from the distant nuclear speck is to kill the whole thread; in a few hours the thread is dead, even to its farthest tip. But though the thread cut away from the nuclear part dies, the nuclear part not merely does not die but proceeds to grow and generate a thread anew.

The cell is clearly a field of action dominated by its kernel, the nucleus. Its nucleus is a nodal point which unifies it. The cell's living field, including and owing to its nucleus, is integrated. Although the cell's life is manifold it lives as one. Its nucleus is a nest of enzymes. Fairy-like agents, they transform as did harlequin in the old pantomime. The house of life rises under their wands. It is the house beautiful or not according as we think, for nothing is but thinking makes it so; and *our* thoughts are the only such thoughts about it. Beauty is a lonely thought, for human consumption solely. Life's house, built as it is, is at least a house of health. A house of *joie de vivre*. Though at times the ferment-tribe may turn aside from health and build a cancer. Then the house can be a house of pain. Could our sixteenth-century physician with his curiosity and earnestness, after he had disabused himself as he did of the influences of the stars on humanity, have peered into the subvisible within the cell, the intracellular enzymes might have afforded him something of that wherein the stars had failed him.

The nucleus is a nest of enzymes, and is par excellence the organ of heredity. Apart from those times of cell-convulsion when the cell multiplies by tearing itself in two, the nucleus is a tiny ball cleanly limited from the rest of the cell by a membrane. Outside it the mass of the cell, although semi-fluid, is far from being a featureless jelly. Rather it is a many-chambered gobbet of foam. Its chambers and tunnels are the scene of many chemical operations. Its framework is no rigid one, but a shifting labyrinth of dissolving walls and floors which form, melt and reform as the work of the chemical factory requires. Somewhere in it reigns the nucleus with a surface-sheet of its own, a special assembly of enzymes. To it the moving contents circulating in the cell have recurrent access. One view of what happens holds that the enzymes bearing a weak electrical charge combine, if of suitable spatial pattern, with the cell-contents of opposite charge moving toward them. The combined product, with some residual charge still left, then combines with a next-comer charged oppositely to itself, if of suitable pattern. The charges satisfied the neutral molecule drifts off leaving the nuclear enzyme free to repeat its work. And so on, cycle after cycle. A single secreting cell can, it is calculated, produce and pour from itself a thousand enzyme-containing particles in every second.

When the cell reproduces itself that internal convulsion of the cell, which ends in rending it, is heralded by contortions of the nucleus. The nuclear membrane as such vanishes. The technique of this study employs dyes; the colourable part of the nucleus, which is the enzyme part, reshapes as short rods easily seen, the chromosomes. The chromosome is an organ concerned in the hereditary transmission of bodily and, as would seem, mental characters. These characters are transmitted in groups. Each chromosome carries a whole set of characters. The characters belonging to the set of one and the same chromosome are said to be 'linked', because they are transmitted together. Occasionally the linked characters are not transmitted all of them together. Observed behaviour of the chromosomes accounts for this. Thus it is that such a character as blue eye or fair hair can be identified with the adventures in the body of a particular microscopic point. At fertilization the separate chromosomes of the two parent-cells combine in pairs. Each chromosome in the one parent-cell meets the corresponding chromosome of the other parent. The chromosomes are thread-like and in their coming together they may get twisted across each other. Then when the fertilized cell tears itself in two, each chromosome—and each is now by-parental—splits lengthwise, and gives one half to each of the two new cells. In this splitting if the chromosome-thread is twisted one part of one may get exchanged for a corresponding part of the other. Then two traits commonly partners are reshuffled. And there are several other ways of shuffling, to extent often not manifest, some traits lying submerged; thus a blue-eyed baby may come to a pair of dark-eyed parents. Traits can thus be identified with particular points in the nuclear thread. As we saw there will be a protein for the hair of a man, a somewhat different one for the hair of the dog, another for the hair of sheep and so on. Further, individually within the species heredity hands down in one man enzymes which bring forth from his food dark hair, in another man enzymes which from similar food bring forth red hair.

The particular point in the chromosome-thread which does this or does that, which is in short identified with potentiality for making an adult trait, is called a 'gene'. It carries an enzyme-system, the enzyme-system for the trait in question. The solving of the riddle of heredity is, we may think, a business for the chemist. Today I fancy no geneticist questions but that the inherited unit-character awaits chemical definition. For instance the Mendelian chlorophyl-defect runs with a specific lack of catalase. William Harvey's epigenesis promises to be in the main an affair of catalysts. The point I would keep in mind here however is that the story of hereditary development seems to us today to be a chemical story. The romance to which evolution keeps adding new chapters is therefore in the main a tale of chemistry.

Heredity deals with us, as though we, whether he or she, are patchworks of characters, and as though in dealing these out to the individual they can be, to some extent, shuffled. Observation finds that in that phase when the life of each of us is held within the compass of a single microscopic cell these characters, in potentiality, lie as a row of points along the length of the nuclear thread. In the little fruit-fly, *Drosophila*, some 2500 such points have been identified and mapped. The mapping has been tested by bombarding one or other point by destructive X-rays. The trait in question is then found to suffer. Our blue eyes, fair hair, and so on are a row of points set out along the nucleus of that one cell which we then are, a row of genes. And the gene? A protein system containing auto-catalysts? A system which within the cell is continued and replenished ultimately from the world outside. The original system of a gene must become billions as the human embryo grows. Yet, at each step, relation to the future trait is preserved, nurture attending as a genius, kind or evil. Among the essential dynamic properties of the chromosomal gene are its catalytic capacity for specific reproduction and the automatic regulation of that capacity. One might think the process would beggar the variants possible even in protein-kind. A little arithmetic relieves that apprehension. Even with only thirty amino-acids to ring the changes, different proteins are possible to a number requiring twenty-three ciphers after the third figure. Set out in numerals it would run across half the width of this page.

Our glimpse of this scene of armies of microscopic agents engaged, swiftly and as if preconcertedly, yet unfeverishly, building a new individual to a plan ripened through countless ages, leaves us with the inference that chemistry holds the key to its comprehension. An ingenious writer has described it as implying a subconscious memory in those millions of cells which perform it. An unconscious memory innately stamped upon the behaviour of each cell in the successive generations which enact it. Our critic, the materialist, would not be moved by such an ingenuity of view. There is nothing to show, he might say, that each phase is not the necessary chemical successor to the next preceding. He finds it a subject where mere ingenuity is out of place. Each modification which the action undergoes in its progress is one which a change in the chemical circumstances makes not only possible but obligatory.

But we may ask does not evolution apply to mind as well as to the body? How then does chemistry come in? The 'how' between mental action and chemical action is still to seek. There is none the less a 100% correlation as regards 'place' and 'time' between finite mind and chemical action in the brain. The equivocality of that 'how' should not, I think, disturb larger facts. Evolution of the mind is as incontestable as evolution of the body. Heredity appears in mental traits as in bodily. It would seem that consentaneously evolution has treated body and mind together. It has envisaged them as complemental features of that which it handles as a concrete unity, the *σύνολον* of Aristotle, the individual, which we might even style the concrete persona. Evolution speaks to us in the same breath of body and of mind.

We saw how our bodily life carries with it its own evidence that its origin is terrestrial. If we employ exotic to mean of non-terrestrial provenance, there is no ingredient in bodily life which is exotic. Its chemical elements are among those commonest on our planet. Its whole is redolent of Earth, whence it was dug. Even likewise with finite mind. Its ways affirm it to be so. Its history proclaims it to be so. Our stock is the vertebrate stock; our body is the vertebrate body; our mind is the vertebrate mind. If the vertebrates be a product of the planet, our mind is a product of the planet. Its activities and proclivities declare it so. Its senses each and all gear into the ways and means of our planet which is its planet. They are adapted to it, as a fish's body to water. Its senses fit the physical constants of the planet's side. Its so-called 'heat' and 'cold' take the body's point of view of temperatures which obtain here. Either side of their narrow range of 'heat' and 'cold', where temperature contains a threat to life, they pass over into pain. Ours is an earthly mind which fits our earthly body. It produces percepts of earthly things from an earthly view-point. It helps the besouled body to deal with terrestrial things, thereby to live. Our mind constructs 'time' and its time's rate is that of its besouled body's terrestrial habitat; although it, not unnaturally, has supposed it to be an universal and absolute Time. The last preceding turn of its planet is its 'yesterday' and the next expected turn will be its 'tomorrow', and the notation of both is taken so that it may exploit its planet better.

"Death and his brother Sleep." In death we are proverbially one with our earth. As to sleep, is there anything in sleep which frees us from earth? Dream? A disorder of earthly fancies—thinking adrift from judgment, so even the better betraying the currents of mortality. Freud saw there an opportunity and seized it. In his hands it proved a key to the reading of earthly misadventures. Then, waking? Is our waking a change from the earthly to the unearthly? Does not waking conjoin us yet more coherently with earth? When our mind truants from an everyday path by means of 'fancy' it still is wholly earth-bound. It may try to break away from our native inescapable soil, but we cannot.

Our imagination in medieval times was greatly in earnest about the Evil One and transmundane demons. Yet its vision could achieve nothing to the purpose beyond contriving ugly hybrids from familiar shapes of terrestrial creation. When Dante's noble imagination travelled the Inferno, Purgatory and Paradise it still walked Italy, the Italy it loved and grieved for. Again that fancied *anima mundi* of Plato is wholly terrestrial fancy. Or if we, accrediting the soul with unearthliness, prefer to entertain the supposition that there is more chance for its unearthliness to show in mediumistic revelation, we have, type of that class, Hélène Smith* and her trance-experiences of the supra-lunary planet Mars and its inhabitants. Nor then was it purely that the words of the medium defeated that extra-mundane scope, because, of necessity, earthly words. Her pictorial representation, automatically produced, of Martian persons, houses, landscapes, plants and insects remained terrestrial, save for a little topsy-turvydom of the Alice-in-Wonderland sort, though not so entertaining. The imagination of the medium during trance, instead of revealing unearthliness, is earth-bound with a banality that the literary imagination does not suffer.

"Many", says Socrates, "are willing to go to the other world from the hope of seeing there an earthly love, or wife or son and conversing with them." Conversationalist as he was he tells us that for himself 'an infinite delight' of that world will be to converse with Odysseus and the leader of the Trojan expedition. To imagine paradise a lofty mind thus invokes its favourite pursuit from earth and a custom of earth's

* Th. Flournoy, *Des Indes à la Planète Mars.*

social creature, man. Mind's earthliness innately shapes all it does, perhaps most so when it tries to be unearthly. Let us not disown mother Earth; rather let us rejoice to call her 'mother'. Earth's nature is our nature. We owe to earth the entire gamut of our mind's wonders, whether of joy or pain. Life's story has been an unfolding of germinal powers of the planet bringing emergence of mind. Let us give thanks where thanks are due. We are, in biological phrase, reactions. The situation creates the life which fits it. The dry land created the feet which walk it. Our situation has created the mind which deals with it. It is an earthly situation. Along with the sea it has created in us the wonder of the sea. The situation engenders the reaction to it. If the agent is terrestrial and the reaction is terrestrial is not the medium of the reaction terrestrial? The medium is the mind.

This might well seem obvious. It cannot always have been so, for there have been other views. Our mind wondering about itself has at times indulged the thought that it is not earthly. It has judged itself to be of 'heavenly' origin. It has so judged sometimes apart from any special revelation of faith. Therefore it is that such a view comes before us here.

The soul, when Omar Kháyyám had sent it on its great excursion, returned with answer "I myself am Heaven and Hell". The Θεός of Aristotle seems in its kind the least earthly and the least anthropomorphic of such conceptions ever drawn. So detached and impersonal does it stand that we can feel it would as observer be the one observer no invalidation by a 'principle of uncertainty' or Niels Bohr's 'principle of complementarity' would limit. As conceived by Aristotle it is the one observer free from reaction with the observed.

A world of our imagining is a world of earthly experiences reshuffled and repieced. The uglinesses of our finite mind are terrestrial uglinesses, e.g. cruelty and egotism; its worthiness is terrestrial worthiness, e.g. prudence and resource; its climax of worthiness, altruistic love, is a sublimation of earthly nature's love. Our mind is part and parcel of terrestrial nature in which it is immersed, and there and only there can it meet with requitals and fulfilments.

What can it point to unearthly in its nature? What has led it to regard itself as not of earth? What signs of unearthliness attach to it? Its own experience is the entire gamut of all knowledge; if evidence of this alleged unearthliness is anywhere it must exist there. We would ask to hear what it is. Our sixteenth-century Jean Fernel held, though he opposed astrology, that our mind is no terrestrial product but derives its nature from the stars. To others again it has seemed even wholly praeternatural. But of that derivation mind and nature themselves supply little confirmation. The naturalist tells us of the finite mind that, as recognizable mind, it has a certain well-defined distribution in nature and is never met with apart from a body, which latter is in no wise praeternatural; and he finds that the mind corresponds functionally with that body. This very correspondence with its body has however been declared a supernatural and miraculous feature. Such a problem does not present itself for those who do not regard the individual, for instance the individual man, as presenting phenomena belonging to other than a single category. For instance, if the mind as well as the body be regarded as some form of energy, the fact that mind and body co-operate follows from their being parts of one homogeneous system. That as the ages pass they change in correlated fashion under the genetic process and environmental stress is but in accord with their being interrelated parts of one and the same system as on this view by assumption they are.

But if the two are regarded as not of one category then to explain the working agreement between them a 'pre-established harmony' miraculously established at outset has been invoked. Precurrent supernatural intervention is called in to 'explain', for example, that the various and different species of bodies embodying finite minds always tally with their specific bodies. The ox-mind in agreement with the ox-body, the tiger-mind with the tiger-body, the monkey-mind with its body, and man's mind with his. The problem can however be treated as a local problem of the planet's side; it can be satisfied by natural processes. There is the fact that finite mind is always observed to be an embodied mind. The body is observed to carry with it the reproduction of the specific finite mind characteristic of that body. The individual breeds true, as is said, and that fact, despite the claim made for the finite mind that it is praeternatural, includes along with the concrete body the finite mind. That is, they both are in the hands of evolution. That they both are so, means that the tally between them in the individual is somewhat that of two malleable stuffs hammered into shape together at the same time between the same hammer and anvil. For each the adjustment so enforced by evolution is adjustment to a surround which evolution envisages, so to say, as one single surround, i.e. for both body and mind. Survival has been the acid test for both. Under evolution the entry of mind upon our planet's scene we read as a further opportunity for fitting life to its surround. "Mind", says one of Shakespeare's characters, "is the slave of life." Mind's errand to life does bear that guise. It is one 'slave of life' the more. It was a further contribution to 'life's' exploitation of the planet's side. Mind became one more tool for life and one more condition amid which life worked. The world became 'object' of it as 'subject'. An image of the world with which it has dealing, this terrestrial world, was flogged into its very substance by suffering as well as by reward. Its innate urge went out toward some things and not toward others. The key of its reaction to them was their use to the 'life' it served. The suitable reaction it often attained painfully; the unsuitable was weeded out of it by bitter experience. Even after the suitable of the particular case had been attained, that was not necessarily the end; the world still changed; what suited once had to be modified. 'Surround' would change and the corresponding life would have to change. Yet, for this finite mind through all as by some magic, its own life, even at worst of times, remained precious to it. Its striving after adjustment with its world was never relinquished, however dire the struggle and experience.

But 'pre-established harmony'! And by miraculous intervention! The conforming of the finite mind with its body emerges in case after case as a hard-gotten gain won from a long running fight with adversity and maladjustment. It has been an outcome in the main of conflict where the nemesis of failure was perdition. Our world we recognize today as a world in making, and ourselves as a part of it likewise in the course of making. Our present is not only not static, its very motion is a motion which will tomorrow not repeat today. Our planetary islet is unfinished even as those island universes which the astronomer tells us are at various stages of becoming. Kant seems to assume the human mind to be a finished thing, a completed item of existence. But the human mind is part of a tide of change which, in its instance, has been latterly and, we may think, still is, running like a mill-race. Living things are all the time busy becoming something other than what they are. And this, our mind, with the rest. It is being made along with our planet's making. We do not know that it ever will be finished. We see it as a provisional *ad hoc* arrangement of the present. Often will it be reminded of this when prosecuting its latest task of establishing the 'values'.

Fernel, could he be with us today, would perhaps see in evolution a triumphant instance of a train of 'purposive causation'. That the train of successive steps led in a definite direction does not necessarily presuppose it set out with a goal in view. The serial steps as looked back at from the latest one of them can appear as though the previous steps were directed toward reaching that, the latest one. Particles swarming round the nucleus in a cell are substrate for an enzyme-series. The product will depend on the substrate and the array of enzymes. Is it our anthropism which as to that series regards one enzyme as 'preparing' for another? A gene would seem to be an heritable substance capable of autolytic increase by assimilation of the substrate. We do but anthropize it out of all recognition if we imbue it with an ideal and an 'aim'.

One doctrine (Driesch) taking from Aristotle the word entelechy—and warping his use of it—declares the gene a tool in the hands of entelechies, for the set purpose of building 'form'. With that we have a retrogression to mediaevalism. Jean Fernel left entelechy as he had found it,* a perfection material in nature. Bosanquet† remarked justly "the attempt to treat entelechy as an element operating *ab extra* upon the material system, when it simply represents the latter in its normal function, must be held purely artificial and fictitious".

Guy Patin, old admirer of Fernel, scribbling in the next century one of his characteristic letters, wrote, "the Rabbis

* Fernel, *Dialog.* i, 3.

† B. Bosanquet, *The Individual*, p. 193.

teach how God reserves to Himself three keys, one fore-knowledge of the weather, one fore-knowledge of our fate, and one of the mystery of life's reproduction. And three fine secrets they are. They are well kept!" As to that last one, life's reproduction, if our materialist in his old frame of mind today submit that he holds the key to it, he can, we may think, go into Court with a good case.

VI

A WHOLE PRESUPPOSED OF ITS PARTS

I define life as the principle of Individuation, or the power that unites a given all into a whole which is presupposed by all its parts.

S. T. COLERIDGE.

Que voulez-vous? La perfection absolue fait toujours plaisir.

JULES LEMAITRE.

VI

"THE organism", says Professor Ritchie,* "over any length of time is essentially a coming and going between the different parts. This interchange is what keeps it all together as a unit and spreads it out into its environment. The organism is the way it behaves and it behaves as a whole." One consequence is that the whole so unified does one main thing at a time. That we would follow now. The statement is not applicable to all types of the integrated individual's behaviour. Its proper field, speaking physiologically, is the neuro-muscular. There we can have no surer evidence of the integration of the individual than the doing of one main thing at a time. And what then is a main thing? It is always one of those acts we call intentional. It may be extensive as muscles go, or quite limited. It is a motor act of such a kind that any other concurrent with it has minimal accompaniment by mind, while it itself has full accompaniment. It can even drain mind off into 'itself'. There are of course motor acts of which quite usually we are unaware; the ordinary snapping of the eyelids is such. But there are a host of motor acts, more complex and more varied, of which we are on some occasions fully aware, at others less aware, and sometimes not aware. There are acts of which it can be said that concurrence with a main act excludes them from awareness altogether.

There are grades of act. We think of ourselves and others as engaged from moment to moment in doing this or that. That is a convenience of speech. Each of us at any moment of the waking day is a whole bundle of acts simultaneously proceeding. Among that bundle is a main or focal one which our conventional viewpoint stresses as the one which at the moment we are doing. Whatever it may be, some of the others of the moment fit in with it, dovetail into it, and in a measure contribute to it, some more some less. Some of these others have little or nothing to do with it. But in no case does any other of all the

* *Natural History of Mind*, p. 184.

doings of the moment disturb the one focal doing. We are each therefore at any moment a pattern of active doing; a single pattern of pieces all subordinate to one keypiece. No other part of the pattern is allowed to disturb the keypiece of the pattern. Should it do so then the pattern changes and the disturbing piece becomes usually the keypiece of a new pattern which supplants the previous. The keypiece is the crown of the unified doing of the moment. Its scope varies immensely. It may be a batsman's boundary hit to leg, or the eye-surgeon's tiny and precise incision into an eye. But always it is of such a kind that one such act engages its whole individual at the time. The individual cannot be the seat of two focal acts at once. In the pattern of doing of the moment the focal act has commonly a number of satellite acts contributory to it, the keypiece of the pattern. A score of contributory acts of posture, and of sensory adjustment, secondarily contribute to give speed or steadiness or precision to the focal act, and of these each one can be and probably has been at other moments a centre of awareness. Of these at the moment our hitting batsman or the operating surgeon is not fully aware, even if aware of them at all. This may signify that only a certain amount of mind is available at any moment. There are phenomena which are subsumed under a mental 'law of constant output' (Spearman). Attention has a certain span which it does not exceed. But the integrated animal's doing what it does as one main thing at a time seems to amount to more than that. Elsewhere focal mind is exemplified by perception or cognition, but here we see it wedded to motricity, 'doing' a motor act.

Sometimes the focal act is not an act perceptible to an observer at all except negatively. But even when purely a train of thought, it carries with it the condition that other acts shall not interfere with it. The state called being 'in a brown study' is an instance. Here usually even the postural convergence of the eyes, in readiness for 'looking', lapses. We, observing one another, instead of inferring mental action from motor action here take motor inaction as a sign meaning 'absorbed in thought'. It impresses on us body and mind coupled as one existence.

The main act of the moment also, for its time being, enjoys a special position. It seems to each of us, amid a natural world which we do not control, a happening which we do control. It seems to me I do it not at the dictation of the inevitable. In turning to it I do not seem to myself to be merely carrying out something already completely fixed for me by the past. I am restricted to one such act at a time, for it is always an act which demands my fully integrated self, I cannot therefore break away from a deterministic world in several directions at once. The integrated thing I am disallows me that. But as to the one main act which I am allowed it seems to me I have freedom of choice. The problem is rather sometimes 'to make up my mind'.

When we converse, to take an instance, the thoughts we are thinking are our main act. In thinking them we seem to be helped by conducting them internally in language, and we seem to exercise a certain choice between the word-symbols to use. But we are also doing other things besides that main thing. Thus there is the utterance of the thoughts. As to the motor acts of phonating and articulating, we seem not aware usually of thinking about them at all! We do not remember thinking about the phonating and articulating. Or, if we stand as we converse, we do not remember thinking about our standing. We can recall that we were standing, that is all. Yet they were complicated things to do, and have to be done and were done with a certain nicety. Was it the mind which was doing them?

Take this act of 'standing'. Suppose my mind's attention be drawn to it, then I become fully aware that I stand. It seems to me an act fairly simple to do. I remember however that it cannot be very simple. That to execute it must require among other things the right degree of action of a great many muscles and nerves, some hundreds of thousands of nerve-fibres and of perhaps a hundred times as many muscle-fibres. I reflect that various parts of my brain are involved in the co-ordinative management of all this, and that in doing so my brain's rightness of action rests on receiving and despatching thousands of nerve-messages, registering and adjusting pressures, tensions, etc. in various parts of me. Remembering this I am perhaps rather disappointed at the very little that my mind has to tell me about my standing. When it gives its attention to my standing it can make me fully aware that I am standing, but as for telling me how it is that I stand, or as to helping me to analyse my standing, I get extremely little from it. The main thing I get from it seems the unequivocal assertion that it is 'I' who stand. We remember that that is an analytic notion which Fernel had not, nor perhaps Aristotle either. If the standing goes on too long I get similarly an unequivocal assurance that it is 'I' who am tired of standing. It seems that this power within me, which identifies itself with me, and calls itself 'I', and wills the body to stand upright, and the body does so, or wills the body to sit down and the body does so, does not know how the body does these things. For all its effort, and for all the attention it can give, it does not seem able to get inside the act which it yet assumes it does. It cannot think itself into the 'how' of the body's doing these things.

How is it the mind can seem to do these things and yet not know how they are done? To stand is an act which the young child has, so the expression goes, to 'learn'. That is so even with an animal which has the advantage of four limbs to stand on. In our adult selves as we stand a fine pointer attached to the top of the head continually slightly sways to this side or that. In other words there are while we stand continual slight beginnings of falling to this side or that, and these swayings are as continually caught up and corrected, even over-corrected. But all that happens without any thought or perception on our part. Our body is balancing itself without our being aware of it, or our mind seeming to take part in it.

We have, and animals have likewise, a pair of tiny water-filled bags one on each side of the head cased in the bone of the skull. Each bag is lined with cells, and a patch of these carry hairlets. A tiny crystalline stone attached to the hairlets rests amid them. The bag has a nerve. It runs from the patch of hairlet-cells to the brain. Any shift of the stone amid the hairlets stimulates this nerve. Through the brain the nerve connects with chains of nerve-centres putting muscles of the neck and body and limbs in touch with the hairlet-patch. When our head is squarely erect, the stimulation from the two patches right and left is similar and equal, because the two stones lie and act symmetrically. The balanced action of the muscles right and left maintains the balanced pose of the head. If the head then incline a trifle to one side the slip, microscopic though it be, of the two stones on their nerve-patches brings the two stones into asymmetry.

The stimulation by them right and left is then dissimilar. From that slip there results the due corrective action of the muscles of the neck and limbs to bring the head back to symmetrical verticality, and secure the required stability. It is the same kind of act as happens when a moving image which is being looked at slips off the central point of sight, and the eye muscles at once shift the eye so as to slip the central point of sight back under the image once again. A whole system of muscles and nerves is constantly keeping the head rightly vertical. The mind knows nothing of this, except the *result*. If indeed it can be said to know what it accepts as a situation without even attentive observation to detail, let alone analysis. It is an ancient system of adjustments, present, variously stereotyped, in great numbers of our stock, forerunners of ourselves. We can see it at work in the sweep and wheel of the gull in flight. Its body inclines with each slope and tilt of the outstretched wings, but the head keeps plumb to the horizontal line owing to compensation by the neck. From that steady pose of vantage the eyes watch sea and ship for food.

These same little gravity-bags in the head work the posturing of the eyes. The eyes contribute to our orientation in space, for instance to our behaviour to the vertical. That orientation was one of what William James picturesquely called our 'common-sense conceptions', evolved, he suggested, by our prehistoric ancestors. But it was in our stock long long before even the subhuman. To deal rightly with visual space the eye-ball, that is the retina, has to be rightly set and manœuvred in regard to it. The pair of little gravity-bags in the head which act on the neck muscles to restore the head's posture, act also on the muscles of the eye-ball to preserve the eye's posture. Whichever way the head turns, slopes or is tilted, these adjust the eye's posture compensatingly, so that the retina still looks out upon the world with its old vertical, that is, retaining its old standard of vertical and horizontal. As the head twists to the right the eye-ball's visual axis untwists from the right. The eye stays as it would if mounted on gimbals in a tossing ship. That these reactions of head and eyes and body which occur when the bird wheels or slants in flight take place unconsciously we may well allow. They do so in ourselves, when the airplane stalls or banks.

Descartes can claim them for pure mechanism. They work themselves, and all our mind knows is the result. The mind is unaware of how we do our standing, walking, running, and so on. The brain as regards their execution does them without mind.

Such facts tend to check an interpretation of animal doings, and indeed of our own doings, which long had currency. The mind was thought ubiquitous in its cognizance of the body, and to be concerned with every act the body did. Our sixteenth-century physician took for granted that the body was conscient throughout. For him, we remember, it was a dwelling tenanted by the sensitive soul. Long after him the 'Nature-philosopher' of a later century supposed that even the curling of a scrap of hide when touched by a live iron, was the act of a *vis sensitiva* inherent in the hide (Stahl). But there are whole regions of the internal organs which are not conscient nor sentient. Even the skin, examined minutely, is not found sentient everywhere. The surgeon finds the brain itself is not sentient, a circumstance which perhaps contributed to mislead Aristotle about the brain and its correlation with the mind.

So too an early tendency was to ascribe every act of movement of the body to, as Fernel in his century would have told us, the soul within. The word *mind* has become in some ways heir to meanings which in the history of language were once, along with others, attached to the word *soul*. It is so here. And using the word *mind*, the old point of view is still current, which tends to attach mind and will to every living movement, even to the fly buzzing on the window-pane. Mind, if we signify by it mind recognizable as such, would seem to be a rarer thing than that. That a cell-aggregate, such as our friend the dog, is in his doings an integrated individual, a system of acts—for that is all we really know him as—and does what he does, we tend to account for by saying he is unified by his mind. As he walks beside us with his ways, and the thoughts we imagine in him, what is the relative contribution to him, as an individual, made by his doings with and those without his mind? We cannot answer fully, but in trying to answer we can review.

One of his motor doings as he runs beside us is though vital relatively simple, and that is his rhythmic taking of breath. We may be sure he does not do that with his mind. We can judge that from our own case. Although when he barks he uses it and controls it as I do my breath in speaking. We know how his rhythmic breathing is done, and although it involves his brain and operates many muscles and nerves, on no grounds can we think it engages his mind. Briefly put, the chemical condition of the air in his lungs is linked by means of the circulating blood with that of the particular part of the brain which manages the ventilation of the lungs. On that ventilation depends the respiratory state of the blood. There is in the brain a spot which, by means of nerves going thither and thence, works the breathing movement of the chest. That spot is so responsive to the state of aeration of the blood that the slightest deficiency of the blood in that respect at once proportionately increases this action of the chest, and ventilates the lung more freely. There is thus a governor-system regulating the taking of breath. It is operated chemically and on the self-regulating plan. As though that were not enough, there is a further regulation, self-operated mechanically. The lungs are stretched somewhat by each taking in of air. The degree of that stretch controls the amount to which the in-breath shall stretch them further. It, at a certain point, cuts that in-breath short, evoking the opposite movement of out-breath. Of all this we judge from ourselves that the mind cannot even glimpse it, however much it pry or try.

As to recognizable mind, observations in disease and experiment show that in ourselves, and in animals such as the dog, destruction of the great front end of the brain, that is the 'great brain', brings to an end all behaviour we ordinarily consider indicative of mind. Memory, the affects, even perception, let alone judgment and altruism are gone. But the animal is still a motor-unity. It walks restlessly about. From lying down it will rise to its feet. It can run. In all this the balance of the body which changes at every step has to be preserved and is preserved throughout. Set upon a moving floorway (Graham-Brown), if that floorway moves under it slowly it steps slowly. If the floorway moves quickly it treads it quickly. If the floorway moves more quickly still it gallops. If, as it stands, the muzzle be tilted upward, the fore-limbs straighten and the hind-limbs crouch, giving the attitude of looking up at a shelf.

Bend the creature's head and the fore-limbs crouch and give the attitude of looking for something on the floor. It can spring, and jump. In falling from a height it manœuvres itself in the air so as to alight duly on its feet. How that result is effected in the air is of itself a sufficiently complex physical problem. But the creature does it, and without mind.

It is clear that here the integration of the cell-aggregate into an individual has made of it a motor-unity. Briefly said, the means which enables that motor-unity is nerve. The nervous system so to say constructs it and works it. The nervous system but not the mind. Conformable with this is, as we noticed, the relation of the mind toward these integrated bodily acts. The mind uses them but it has no knowledge of their working any more than one who drives a motor-car may have of how it is the car does what it does. The mind is utilitarian. By evolution it is bound to be so. Each step of its development has had to justify itself *ad hoc*. What evolution looks to is use to the individual as a going concern—that would seem perhaps the one thing it does regard. If the mind finds its animal body possessed of integrated movement adequate to certain results, what advantage, we may ask, would accrue from the mind's experiencing the detailed 'how' of them? Long before there was any mind which could pry into these things animals were doing them. What is wanted is awareness of the direction and extent to which an act changes the perceived situation, and that the mind provides. That counted for survival. To provide anything more than that would seem mere 'scientific curiosity'; a work of supererogation.

We ask regarding this motor individual, "Where and when the mind does not operate it, what does operate it?" We are wont to think the organs of sense, the ear, the skin, and so on, not only gateways open on the world but also gateways open to the mind. Some of them become that; a provision for the perceptual mind. But the rôle of a so-called 'sense-organ' very commonly does not involve sense or mind at all. It may or it may not be a gateway to the mind; it is always a gateway to the motor individual and its injunction to that individual may be to move or not to move. Just as a sense-organ, when it justifies its name, may be a means for starting and stopping thinking, so in the motor individual it is a means of starting and stopping motor-acts apart from mind. In this latter case it is misleading to call the organ a sense-organ. To call it 'receptor' or 'analyser' avoids that misconception.

Highly selective as to what it will respond to, each modality of it needs a particular class of agent for its activation. It is like a door which says 'ring' where knocking gets no answer. The series of these organs taken together thus selects, though crudely, what is passing in the world. Thinkers, in the Middle Ages and before then and since then, have rebelled at cognition being an outcome of the senses. Revolt against the 'tyranny of sense' has been a factor in predilection for 'revealed knowledge'. The senses were gross and bodily and tied man down to brute creation and the earthly. The intelligences of the stars surpassed human perfection by not requiring sense for their knowledge which was a divine gift. The peccadilloes of our senses were often insisted on as a warning against trust in 'sense'.* The greatest of their deceptions, namely that Earth stands still, oddly enough continued exempt from blame, and actually defended by authority long after popular knowledge had freed itself from this illusion. Today, with the evolutionary story of the mind, and the facts of the development of the nervous system, Aristotle's old insistence on intellect as rooted in sense holds more demonstrably than before. Physiology can even tell us that consciousness wholly lapses when stripped of sense.

To affect the mind is part only of what a receptor-organ does. As receptor pure it signals to the motor individual pure. This latter does not perform any miracle of mentally interpreting a signal. It simply converts the signal into a releasing force for an act. In the complete and organized individual the two results when, in their two separate spheres they occur, pragmatically tally. What arises in the mind concurs with what is provoked from the motor individual. It seems to the doer that the reading of the situation by the mind determines the doing provoked from the motor individual. Sometimes, however, in the experience of most of us a sudden situation of urgency is met by our individual doing the right thing before its mind has grasped the

* For citation of a fourteenth-century indictment of the senses, cf. Lynn Thorndike, iii, 451, dealing with Nicolas Oresme on 'Nature'.

situation. In the street's traffic we jump aside and leave our mind surprised that we have done so. We avert an unexpected blow before our thought has warned us. Our hand has caught the fragile cup as it fell before our mind seemed fully aware of its falling, let alone, could issue orders for its saving.

The motor individual is driven from two sources. The world around it and its own lesser world within. In both cases through its selective receptors. Its activity is also partly operated by nervous action arising spontaneously within the nervous centres themselves. It can be regarded as a system which in virtue of its arrangement does a number of things and is so constructed that the world outside touches triggers for their doing. But its own internal condition has a say as to which of those things within limits it will do, and how it will do them. Its own internal condition is also initiator of some of its acts.

Descartes stands as a new starting-point for the view of living creatures working as machines. In the century previous to him our physician Fernel argued that the motor act cannot be subsumed entirely under will. In regard to the body and its motor acts he had there departed avowedly from Aristotle. Aristotle thought of motor acts as in every instance an appanage of mind, namely of that activity of mind which is desire. Desire could be rational or irrational. It served both emotion and the deliberate will. Desire, however, being an outcome of that primary function of life, sensation, and bodily movement being an outcome of desire, bodily movement was a secondary outcome of sensation, and so under Aristotle's analysis bodily movement disappeared from among the *primary* functions of life. Fernel does not feel satisfied about this. He is at pains to insist that there is bodily movement distinct from sense and will. He says* that Aristotle has not been sufficiently explicit about this. He remarks—and here the versed physician comes to evidence—that in disease sensation may be lost and the 'will' be impotent and yet movement occur. He points out† how in ourselves, though the act of willing a movement is often obvious and unmistakable enough, we even more commonly make movements of which we cannot trace 'will' to

* *Physiol.* v, 9, 109*a*, *i.e.* c. 8 of the original edition, 1542.
† *Physiol.* vi, 13.

be the 'cause'. He insists in short on the existence of a class of motor acts, animal and human, in which the thinking-soul takes little or no part. Thus, he cites * movements of the eyelids, certain movements of the eyes, the movement of breathing, certain movements occurring in sleep, etc. The movements of the eyelids commonly take place unwilled and pass commonly even unremarked. We breathe in sleep and neither will the movement nor sense it. Thus certain of our motor acts are not traceable to or accompanied by mind at all. In calling attention to these facts Fernel was establishing—and it would seem originally—a position which newer knowledge amply justified. It is well recognized now that there is a class of motor acts which, although simulating acts of mind and having to appearance a purpose, e.g. the blink of the lids protecting the eye, thus being appropriate to circumstance as though the mind did them, are in fact, for any ordinary acceptation of the term 'mind', wholly mindless. Fernel here was starting not only a new chapter in the study of the nervous system, but indeed something new as to the ways of living nature.

In the next following century, some ninety years after Fernel, Descartes took up this theme. Acknowledgment of the source of views was relatively little practised in the scientific writings of that time. Descartes made no definite reference to Fernel, any more than did Thomas Willis, coming later, to the writing of Descartes. We can, however, scarcely suppose that Descartes, who, to prosecute his favourite 'anatomy and physiology', actually entered on medical study at Amsterdam, † had not read Fernel, the standard treatise on physiology of that day. Moreover, as had ‡ Fernel before, Descartes invokes the pineal gland to act as valve controlling the passage of animal spirits between the forward and hindward chambers of the brain. Guy Patin contrasts Fernel with Descartes; in the thoughts of many of that time the two names ran together. Whether Descartes' view was actually original with himself does not of course matter to us, or to the view. Certain it is that Descartes, developing the doctrine of mindless motor acts in man and animals, put it forward with a force and clearness which caught

* *Physiol.* vi, 13. † Letter to Mersenne.
‡ *Physiol.* vi, 13.

the abiding attention of the world. He said in effect 'the bird or dog of which we imagine as it flies or runs, that its act is conducted by thinking, willing and so on, is not so actuated. Its movements are in truth just the running of a wound-up clock. So likewise with many of our own motions, yours and mine'.

To quote a passage from him:* "And as a clock composed of wheels and weights observes not less exactly all the laws of nature when it is ill-made and does not tell the hours as well as when it is entirely to the wish of the workman, so in like manner I regard the human body as a machine so built and put together of bone, nerve, muscle, vein, blood and skin, that still, although it had no mind, it would not fail to move in all the same ways as at present, since it does not move by the direction of its will, nor consequently by means of the mind, but only by the arrangement of its organs." Or again in a passage which can be looked upon as final with him—for it occurs at the latter end of the *De Homine*, to be published posthumously—after rehearsing various actions of the body he says,† "I repeat I want you to regard these functions as taking place naturally in this machine because of the very arrangement of its parts, neither more nor less than do the movements of a clock or other automaton from the weights and wheels, so that there is no need on their account to suppose in it any soul vegetative or sensitive or any principle of life other than its blood."

This standpoint was in effect new. There is little foretaste of it in Aristotle. Perhaps its nearest there, is a dramatic little sentence in the *De Anima*.‡ The watcher at night, if the torch of the enemy move, dips his head automatically. This is today's 'protective reflex'. Hamlet's "sense sure you have, else could you not have motion" is Aristotelian and indicates that in the generation before Descartes 'reflex action' was not among current ideas.

Let us here take a liberty with our subject. Let us suppose processes in the brain which correlate with mental processes, these latter, not the purely sensory but processes more complex, concerned with relations between the items of our experience. Let us think of these as possibly arising locally in the brain. In

* *Meditationes*, vi. † *De Homine*, iv. ‡ iii, 7, § 5.

order to distinguish them from those which arise outside the brain in the receptor or sense-organs, let us label them 'intrinsic' and think of them as, especially in ourselves, belonging to the roof-brain. Assume for the moment, against the position of modern science, that the correlation of brain and mind amounts to what we may call a *contact utile* between them. Then these 'intrinsic' roof-brain processes correlate pragmatically with the noegenetic processes which create, in the broad sense, knowledge.

The roof-brain processes which arise intrinsically let us label 'intrinsic', to distinguish them from sensory processes which arise quite outside, 'extrinsically'. The two are not, however, in watertight compartments. Thus, the 'intrinsic' can be evoked via the sensory, for instance, in the elaboration of these latter perceptually. The 'intrinsic' are, however, quasi-independent of the sensory. The sensory are similarly quasi-independent of the cerebral 'intrinsic'. Each can occur without the other.

Let us suppose that both the 'extrinsic' and the 'intrinsic' are in touch with the organs of movement and can operate them. When the 'extrinsic' do so independently of the 'intrinsic', that is reflex action. When the 'intrinsic' do so independently of the 'extrinsic' a form of 'willed' action results. Our normal motor behaviour would then consist in a harmonious combination of the 'extrinsic' and the 'intrinsic'.

As we descend the scale of animal being, e.g. pass from the vertebrates of more elaborate nervous system to those of less elaborate nervous system, the normal motor behaviour is operated relatively more and more by the 'extrinsic' processes with less and less of the 'intrinsic'. Even in vertebrate types with the greatest elaboration of the nervous system and the fullest development of 'intrinsic' roof-brain processes, parts of the motor behaviour are still operated almost wholly by 'extrinsic' processes, i.e. are purely reflex. But even with the simplest vertebrate systems we may think that in certain items of their motor behaviour there is, along with operation by nervous processes of 'extrinsic' origin, a certain contribution and participation by 'intrinsic' processes.

Throughout the whole series of these animal forms the 'extrinsic' and 'intrinsic' processes operating the animal's motor behaviour dovetail harmoniously with one another. The smooth perfection of motor behaviour in the animal world is a demonstration of that. A problem of the physiology of the nervous system is to make out how the 'extrinsic' processes (the reflex) and the 'intrinsic' processes (the non-reflex) co-operate and interact without occasioning inco-ordination and confusion. A weakness of the Cartesian position—perhaps rather of his followers than of himself—was omission of consideration of the 'intrinsic' participant in the behaviour of the motor individual both infrahuman and human.

Descartes' 'automatism' was a great event in physiology. And it had notable repercussions beyond. We need not, even were I competent to do so, enter upon them here. For one thing it re-equipped 'materialism'. At the same time it freed the finite rational soul from obligations to matter as rarely had it been freed before. It took from it the burden of operating matter. The course of scientific discovery has since then conspired with this view of Descartes to cut the individual into two disparate halves, mind and body. That severance is pronounced a paradox by Nature and by Evolution. Nature and Evolution deal with the individual, body and mind together as a unity.

Descartes' biology still possesses for the biologist an interest not merely antiquarian. Its primary touch is with anatomy, yet with anatomy for the light it can throw on function. Descartes was not a physician. He had not therefore the physician's opportunities for conversance with birth and death. But he was not simply an arm-chair biologist. He gave long hours to dissection. He early seized the fact his senior contemporary, William Harvey, had recently announced, the circulation of the blood.

Acquainted at first hand with the gross anatomy of the muscles and nerves, Descartes pondered much on the motor acts of the body. It was a favourite problem with him. Unlike Harvey, however, he did not devote time to checking his suppositions by experiment. Nor in his largely supposititious description of the motor working of the body does he give any caveat that it is indeed unchecked supposition. He wrote his *De Homine*, sometimes called a physiology, to describe how man moves as an automaton. It was a work of genius.

Thus, purely *a priori* it assumed that the motor act required an inhibitory process along with an excitatory. This idea was original with Descartes. Experimental physiology 250 years later confirmed it. During Descartes' life his *De Homine* was circulated in MS.; its printing was posthumous. What it stands for is well illustrated by a sentence from Charles Richet,* writing in our own time: "Created things are in truth, as Descartes foretold, machines. Machines extremely delicate and complex, but machines none the less. They are arranged so that they react according to infrangible laws to external forces. The necessary reaction of the creature to the changes which affect it gives that seeming spontaneity of doing which in fact is only inevitable response. Its action is always a response and inescapably conditioned. If the response appears often disproportionate in amount to the circumstance which evokes it, that is simply because the relation is between a releasing force and the energy available for release. Especially is this so with the nerve-cell; it responds as purely mechanically as any muscle." There is nothing to startle us in this. But it would have startled the general reader of Jean Fernel's time. Today that our muscles are machines seems to go without saying. The biologist talks of their mechanical efficiency, as an engineer might of an engine. The maximal efficiency for the whole cycle of muscular contraction including recovery is in man, says Professor Vivian Hill, something over 20 %—and for the frog not much less. To envisage the parts of the body as machines has its use and carries its inferences. It lets us assess, for instance, the technical economy of living movements against that of man-made machines. A machine being a man-made contrivance, to call a living organ a machine implies that it is mechanism humanly intelligible. The whole man being organs the implication is that the whole man is mechanism humanly intelligible.

That is a notion probably unthinkable to Jean Fernel. For him the actions of the parts and organs belonged to 'life', a mystery not given to man to penetrate. We might observe the outcome, and the analogies, but the intimate 'how' of them lay beyond us. *A fortiori* did that of our integral bodily activity. To suggest that bodily life is explicable as a machine is explicable

* *Physiologie des Muscles et Nerfs*, p. 898.

would for Fernel have been antithetic both to his natural philosophy and his religion. Richet we notice goes further. He applies machine to the whole created thing, the individual. Endorsement of that will depend on how we view the mind. Fernel would have dismissed it as he did Democritus and the atoms. His faith in 'freedom of will' alone would have sufficed to reject it. Apart from that and from him, there are those to whom one thing clear about mind is that it is not energy.

And if not energy, is it possible to conceive it a machine? Perhaps for Spinoza the mind, obeying its laws, did come near to being machine-like. But for most of us the imperceptibility of mind removes it too far from our experience of machines to make helpful likening it to a machine. Besides a machine preaches to us of purpose all the time. But that is scarcely so with the mind. Plato used to liken the human soul to the State. The gap between 'the State' and 'a machine' is not so wide. Descartes, however, expressly excluded 'reason' and 'will' from his machinery of the individual. Those apart, Descartes' individual was a machine. Now that machines have so multiplied and developed about us we may miss in part the seventeenth-century force of the word in this connection. By it Descartes said more perhaps than by any other one word he could have said, more that was revolutionary for biology in his time and fraught with change which came to stay.

Descartes' view of man's doings was in line with his view of the doings of the physical universe. He was bringing them both into one picture. He founded the behaviour of the newly discovered Copernician universe on a conception of vortices, which it was left to Newton to show did not adequately satisfy the observed facts. Descartes' automatized doings of man were of a piece with his automatized doings of the heavenly bodies. The principle of the motion underlying the celestial movements and of that executive of the life of the body he took to be one and the same. The same motion; the same mechanics. He did without the 'unmoved prime mover'.

But if he meant, and in various passages he does seem to mean, that, just as man is an automaton with superadded mind, man's kindred, the brute creatures, are automata without mind, his opinion lies today where he left it. In some ways the mediaeval adhered to Descartes. The mediaeval view generally denied to brute kind any loftier status than that of terrestrial furniture provided for man's use during his probation here. The Cartesian lack of sympathy and understanding in this matter of creature-kind went further, an unaccountable trespass both against our fellow-creatures and against common sense. Even supposing, and it is a questionable supposition, that St Francis' 'brotherliness' with all that was animate, was, despite its phrasing, not a sympathy recognizing kinship but simply part of a love extended to everything created by God and essentially a worship of Him, even so such a view was venial blindness as contrasted with the ruthless Cartesian rupture of the traditional stair of life ranging upward step by step to man. Science since Descartes has repaired the stair and finds it more significant than before. It marks the way that man has climbed. And it is a stair of mind as well as body, and it is without break, man's mind nothing more than the topmost rung continuous with related degrees below.

Descartes—to dwell on his picturesque and dominating figure a moment longer—is a landmark both of the mediaeval and the modern. "Le plus grand géomètre de son siècle" was also among, if we may coin the term, the romantics of cosmology. His *Le Monde* in Molière's day delighted society, 'le beau monde'. Sophie exclaims in *Les Femmes Savantes*, 'J'adore ses tourbillons'. Today his conception of the doings of man still finds its echo in official Russia. The citizen there, taken *en gros*, seems to be viewed as a system of reflexes. The State can 'condition' and use these systems of reflexes. 'Reflexology', as it is there called, becomes a science of man on which the State leans. In 'reflexology' Descartes would find Ivan Pavlov of Petrograd his greatest successor; and the successor was an experimentalist as Descartes was not.

If the term reflex be applied wholesale to human and animal acts simply to imply that all these motor acts are traceable back through a chain of physical events to initial physical events whence they necessarily follow, there is no need to employ the word 'reflex' for that. All the items of motor behaviour are mediated by the nervous system and that system is a physico-chemical system and all the happenings in it are chains of physical events with the statistical probability which attaches to such. There is in that nothing distinctive of reflex-action as against other bodily happenings of all kinds. Nor is it that among the actions of the nervous system the reflex stands out as the only mechanistic one. An interest attaching to it is that its mechanism is probably that nervous one about which we know most, because of its relative simplicity.

As to the term itself, Descartes in describing his automata did not say 'reflex', or rather he scarcely did so. It is to be found once, and then not in substantival form. It was Willis, Professor of Medicine at Oxford, who writing, rather later, on the nervous system, gave numerous instances of automatic acts, where stimulus was promptly followed by movement without conscious participation of the 'will'. He spoke of this action as being 'reflex'. The 'animal spirits' ran up a sensory nerve, reached the nervous organ and thence ran down the motor nerve. These acts were all of them simple. The lifting of the touched foot in sleep. The closing of the touched eyelid. The position they created was a long way from Descartes' position, nor does Willis mention Descartes. But it was an observational beginning, a basis of fact further exemplifying Descartes' view. The next century brought more such observations, some of them observed with better control under experimental conditions. Robert Whytt, here in Edinburgh, showed how the frog's spinal cord *per se* without the brain suffices for many reflexes. Then, later our breathing was found to be essentially reflex. In animals more reflexes and more complex reflexes came to light. Later still there was reached that picture which we glanced at, of a reflex creature which not only breathes and stands but rises and walks, or runs and attitudinizes looking up at a shelf, or scanning the floor. A notable approach to the Cartesian idea.

As advance proceeded some features originally supposed of reflex action had to be modified. One such feature had been machine-like monotony of result. 'Reflex' suggests analogy to reflexion of light from a mirror reversing the light's direction but otherwise leaving the light-beam little changed. That analogy was not well taken. The nervous reflex is a release reaction from start to finish; a release reaction is not quantitatively its own master. In reflex action that is especially obvious at the reflexion point. There great modifications may occur, a large explosion or a complete suppression. Monotonous regularity is likely only with the simplest reflexes where variable factors are few and can be guarded against.

A very simple reflex is the 'knee-jerk', which the physician uses as test of nervous health. It is a slight quick straightening of the knee to a light tap given below the knee-cap. Its variability is its main service to the physician. His tap on the tendon releases within the muscle a nerve-signal which on reaching the spinal cord fires one back again into the muscle, making the muscle twitch. That is all; but how delicately variable. To secure regularity the knee and the whole body must observe a standard pose. The attention must be diverted; if not there will be irregularity of response. By its means the physician tests the state of different parts of the nerve-system. The brain, the cerebellum, the centres for ear, the bulb, parts quite remote from the knee's own nerves and nerve-centre. The reflex has, as it were, its fingers on them all; or rather they on it. Some exalt it, some depress it. The experience of the physician reads from it those influences and judges if they be normal. The nervous system stands revealed as a unity articulated together; and each part of it feels the touch of other parts.

With this co-operative jointing together of the components enters that factor which disturbs the earlier notion of the fixity of reflex action. A reflex movement operated from one source is modified by a reflex operated from another one, even distant. Let the reflex creature in its walking hurt its foot; the reflexes over almost the whole animal are altered. The pricked foot itself is at once held up out of harm's way; the other legs start running.

Signals convergent via many lines may in the centres coalesce and reinforce. It is in the centres too that there appears a process which quells excitement instead of evoking it. This is the process postulated by Descartes, *a priori*. Voltaire in his caustic vein wrote of Descartes, "au lieu d'étudier la nature, il voulut la deviner". The remark had its truth; but in this postulation of physiological inhibition, Descartes not only would but did *a priori* divine a Natural fact and process, which only two centuries later did physiology discover by experimental study. That a muscle on irritation of its nerve contracts, was already known in Alexandrian times. In the seventeenth century Descartes postulated an activity which suppressed activity. It waited for factual confirmation until the nineteenth century. Then at first it was not believed. Several who witnessed the fact did not report it, hesitating to accept it as true. Descartes had made this postulate when thinking out his supposed Robot-man and how it should work. The nerves of the muscles which turn the eye-ball sidewise he had particularly in mind. Those muscles are arranged as antagonists. Instead of one pulling against the other, he supposed one paid out as the other drew in. It was paid out by inhibiting its activity. He was right. The inhibition is however actually exerted not directly on the muscle, as he thought, but on the nervous centre driving the muscle. It acts within the nervous system itself. It is a factor of wide importance in the management of muscular acts throughout the body. Occurring in the brain it will presumably affect the mind.

A nerve-centre is a place of junction of nerve-lines, and of departure for fresh ones. It is at such junctions that inhibition occurs. It can there suppress action, or, no less important, can grade it by moderating it. In the network of conductors it can switch off one line as another is switched on. Hence what a reflex does at one time it may not do at another. With excitation weighting against inhibition a different ratio between the two tips the balance differently. A drug may in a second reverse a reflex, by favouring inhibition or excitation. Patterns of reflex response shift like the pattern of a tapped kaleidoscope. All this tends to bring the variability of animal behaviour within the grasp of reflex action and of Descartes' automatism.

The old conception of a reflex as giving one uniform result forgot the complexity and instability of the internal mechanism. The external conditions may be alike but the internal state of the mechanism not the same. A mirror reflexion from a pool depends on whether the surface ripples or is quiet. A bubble and more change still. Some reflex centres are in fact 'bubbling', i.e. spontaneously discharging. Where reflex mechanisms are articulated together the upshot on any given occasion may well be unpredictable by an observer, who knows only that the penny went into the slot. Watching an animal as it reacts from situation to situation the observer will be at a loss to foretell from minute to minute what next it will do; and yet it may still be reflex. A reflex offering alternative results is still a reflex. The observer may say, "here we have spontaneous will at work". Statistically, he would find it predictable behaviour. Our own is such.

Historical importance attaches to the conception of reflex action. At a time when nervous function lay involved in mystery, and therefore at the mercy of the occult, the 'reflex' introduced a category of nervous action so simple and straightforward as to be free from the mysterious. It made an excellent start for scientific analysis of nerve. But the *a priori* imaginings of Descartes allotted a more extensive field to the reflex in man's acts than the facts and reflexes of Willis, Whytt and others, even a century later, confirmed. The purely reflex man, as demonstrated by disease and injury, to clinical observation, is an attenuated shadow beside the robust human automaton of many-sided reflex capacity depicted and planned by Descartes. The real importance of Descartes' step was that it handed the work of the nervous system over to the nervous system itself. It had been worked by Galen's spirits and the soul. And when reflex action as such proved unequal to much which Descartes' Robot stood for, the Robot idea still stood. It still continued to attract doctrinal followers, though the reflex paradigm was not fully adequate to it. Descartes still remained representative of the idea of living things as mechanism.

Coleridge said of a machine that it is a man who can do but one thing. A man, says Charles Richet, is a machine which can do a number of things. That is true if we take the things he does apart from his mind. But he is a machine with a mind. Does that make a difference? Yes, it enables him to do, in addition, things on a different plane of cognition and intent from those other ones; it enables him to do 'main' things. But only one at a time. Richet might say that his having mind does not rescue him from being a machine. If that were his view there is more than one standpoint he could take. One is that mind has its uniformities, its 'laws', just as much as has either matter or energy. Or he might appeal to the scientific exclusion of mind from all ability to influence any energy-machine, the human included. Therefore how far we here agree with Richet will still rest on what view we take of mind.

That turns us back for a moment. The motor act as conative would seem to have been the earliest nurse of infant mind. Not the germ of mind, nor the parent of it. As to its parent, who shall say? Had energy a parent? Then why must mind have one? Rather let us seek where we can first trace mind, or where we last lose it. Does it not begin with urge to live? Zest to live which is part and parcel of life? Is it not that all through? Becoming gradually more sophisticated? The zest of the living thing to go on living, and renew itself as a new life. The zest which implements the whole conduct of life; the zest which the whole conduct of life implements. At once an urge, a motive and a drive. No species of life without it. Innate, inalienable, impelling alike man and animalcule. A character which in the more than millionfold variety of nature's types does not fail or falter in a single one. Individual minds of endless variety of type, reptile, fish, bee, octopus, ant. Man observing them, wrapt in his own anthropism, finds some as strange in mind as in the bodily forms that clothe them. Some on still closer knowledge become to him still more strange; some on closer knowledge hateful beyond all tolerance; some delightful to know more closely. But in them all, whatever else, this constant trait; the drive to live and increase. We can call it zest, and zest it often is, but who shall say where, traced along life's scale of forms receding from man's own, zest becomes blind drive, and drive retreats into mindless urge. It may be mind still, although mind 'over the horizon'; for all description 'teasing us out of thought'.

It was panegyrized years ago as 'will-to-live'. But that was a misconception and despite its intention sadly inadequate to the fact. As well call an ocean-tide which sweeps the mariner onward his 'will'. As well suppose we summon the Spring's growth by asking for it. To think of the vast nether flood of 'urge-to-live' as mere 'will-to-live' is to miss the meaning of the whole subconscious world whence man has come, and in part still belongs. Urge-to-live is an immense natural situation, greatly older and far wider than 'will' can embrace. It was a biological 'law' before 'will' came to be. I remember sowing into 2 litres of 'distilled' water contained in one of a pair of similarly filled tall glass jars a minute speck of a culture of the cholera germ. I added this speck to the clear water just before leaving the laboratory late in the summer afternoon. The water in both the jars was then crystal-clear. Next forenoon, to my extreme astonishment, the whole tall column of water in the one jar was faintly opalescent. I microscoped a drop. It teemed with myriads of cholera germs, the progeny of my speck of the day before. An almost incredible multiplication. But a philosophy which dubs such a phenomenon 'will-to-live' adopts melodrama. To gunpowder its lyricism would impute a 'will-to-explode'.

Whence has it come? This power to multiply? Granted a protein which self-ferments its own growth; and give it its conditions; what then shall stop it? Earth does give it its conditions, and it goes on. By so doing it creates the biological situation we know and it implements biological evolution; its condition of always providing excess forms the impetus. When and where recognizable mind obtains for the concrete life, that mind will fit that life because that life is a condition for it. That mind will combine with 'drive-to-live' in the form of 'zest-to-live'—'conservation of the self'. That this continually budding plastic and aggressive thing should among its other doings have fashioned man, we can understand. But man, reached, is no halting place for it, it will not stop there. Man and those other things sample what under terrestrial conditions it has done; they are but an earnest of what it can do, and of what will be done by it. The question we ask is 'can man take control'?

When it was found that relatively complex acts, such as standing, walking, running, turning the gaze, rising to the feet, etc. are elicitable in an animal such as the dog under conditions precluding consciousness, the notion of reflex action as underlying large fields of our own motor behaviour gained ground. Such trains of motor behaviour might be operated reflexly even in the conscious individual. Reflex action appeared as adjuvant to our conscious motor behaviour.

This would let us understand how in the doing of some conative act, e.g. drawing a sketch, the consciousness of the act seems to restrict itself to a focal part of the act, e.g. to the hand's guiding of the pencil, while many concomitant but subsidiary parts of the motor act, e.g. the general posture of the body, do not seem present in the consciousness of the moment. It was suggested that such are left over to reflex action. It would be an economy for conscious mind which keeps its total simultaneous activity a level quantity, though variously distributed.

The 'unconsciousness' of habit seems something different. An act which in the learning required full attention becomes by repetition so facile that the mind can wander from it and it may be done better then than if attended to. The pianist will tell us that his thought can wander from the keys and music during the execution of an often practised passage. The skilled machinist employed in a routine process says that while she does it she escapes monotony by following her own day-dreams or by conversing with companions. Some, while they knit effectively, will read aloud a novel for the enjoyment of the room. To say in such cases the act which does not engage consciousness is operated reflexly, is to strain the ordinary meaning of 'reflex'. The helpfulness of the term lay originally in its indicating a type of reaction where a relatively simple external stimulus evokes a nervous reaction for which consciousness was no necessary condition. But these skilled acts rendered 'unconscious' by habit are not evoked by external stimuli. They have been acquired by reiteration of a mental act. Even of a train of ideas. They are reactions to a mental situation rather than to any simple stimulus. So with a dog whose mouth waters at sound of a tuning fork, which training has associated for it with offered food. These trains of reaction have become automatic, though at first attended by acute and critical awareness. That they now proceed apart from attention does not bring them into the category 'reflex action'. The reflex is independent of consciousness even at first occurrence. It does not emanate from the 'ego'. The reflex is innate and inherited.

The acquisitions of habit present neither of these features. They are results of training. They are parts of education, whether formal or 'natural'. Habit is a charitable economy relieving the 'I's' more costly mental action. The 'I' has this labour-saving device of truanting from the habitual. But the pure reflex is a school at which the 'I' never was. To have the full pressure of mind which can be had for an act, it seems helpful not to dissipate any on what can be done by habit. The practised marksman settles into a posture so habitual that he can forget it. If a habit have much mental accompaniment it is not yet acquired. Under the faculty-scheme of old-time psychology the teacher might have expected the acquisition of one habit to facilitate habit-forming in general. That would have had besides its conveniences its dangers:

> Mais tous ceux que sa force obscure
> A gagnés insensiblement,
> Sont des hommes par la figure,
> Des choses par le mouvement.

There is no 'faculty' of habit, and acquisition of a habit is specific and not 'transferable' beyond its application. It is *ad hoc*; a faithful servant in its place. It is for the master to assign to it with care its particular job, for it is unlikely that a job once assigned it, the master will ever himself do that job again. So our wise poet:

> Travaillant pour nous en silence,
> D'un geste sûr, toujours pareil,
> Elle a l'œil de la vigilance,
> Les lèvres douces du sommeil.
>
> Mais imprudent qui s'abandonne
> À son joug une fois porté!
> Cette vieille au pas monotone
> Endort la jeune liberté.

Habit is, however, not 'reflex action'. Can a reflex be acquired by exercise of mind? Can a habit be acquired without exercise of mind? Habit is part of education. Both reflex and habit are in effect means of economizing mind. But we have still to find that they are both the same.

Reflex action has contributed much to the integration of the individual. It would seem to be reflex action and not mind which primarily integrated the motor individual. The simpler motor acts were there before the mind—always meaning by that 'recognizable mind'. As we look along the scale of life, whether in time or in order of organization, muscle is there before nerve, and nerve is there before mind, 'recognizable mind'. It would seem to be the conative motor act under 'urge-to-live' which has been the cradle of mind. The conative motor act, mechanically integrating the individual, would seem to have started mind on its road to recognizability. The great collateral family tree of life, the plants, despite all its variety and unexampled profusion of types, has never in any of them developed an animal-like motor act, nor a muscle nor a nerve; it has likewise remained without recognizable mind. As motor integration proceeds, mind proceeds with it, the servant of an 'urge' seeking satisfaction.

Our sixteenth-century Fernel viewed the body as a tenement for faculties. One faculty was that which actuated the various bodily movements. Then came Descartes with his Robot, a mechanism actuating itself. Such too had been Descartes' thought with regard to the motions of the macrocosm. For Kepler still, a century later than Fernel, each planet was ridden by an angel. Then later with the 'reign of law' that guidance became a 'force', e.g. gravitational. Today the 'force' has in its turn disappeared. There remains a curvature of space. The human mind looking at Nature has had to dehumanize its point of view—it has had, using Alexander's word, to 'deanthropize' itself. In the view of some it has still to dehumanize itself further. It has to dispense with 'causation', which is regarded as an anthropism. The above change in conception of the motion of bodies is however no impugnment of the notion of causation. It has, however, advantageous simplicity; instead of invoking a supra-sensual principle it uses a conception plain to sense. It is more faithful to William of Occam.

It can be said that to pick out this or that particular contributory condition in a conspiracy of reaction and to label that particular one the 'cause' is arbitrary and artificial. The plain man, however, we may think, indulges in that habit where under a certain set of circumstances a change in one factor observable by him is followed by change which he can predict from the former. To do so has pragmatic value.

The Cartesian supposition that our brute friends are simply reflex automata has its kernel of truth. In our friend the dog, reflex action covers a certain field of his doings. But what field?

The following sample it. His standing, his lying down, his getting up, his walking, running, jumping, even swimming, keeping a hurt foot off the ground, shaking his coat and ears when wet, snarling, seizing food, eating and drinking. These sample it in their execution—not as acts of 'behaviour'. Stereotyped 'acts' of dog-nature though they are, our dog-friend when deprived of his 'recognizable' mind does them still in the absence of that mind. But he does them then inconsequently; inconsistently it may be with the situation, or with their own consequences. He snarls even when lifted from his litter to receive, as custom should have taught him, his breakfast. He laps up what his stomach will reject even as he does milk. Such show how the pure reflex being non-mental is a reaction detached from its individual's past and future time. It is detached consequently even from his 'now', for although it serves a purpose its purpose is, like that of Aristotle's 'Nature', an 'unconscious purpose'; left to itself it will execute that purpose as likely at a wrong time as at a right. This descends to levels far lower in the life-scale than that of our good friend the dog.

Reflex behaviour is not attached to the individual's time-scale because the pure reflex is outside of 'time'. The sparrow that flies up the roadway as the car comes on forecasts 'time' as no purely reflex sparrow could. The bird reseeking its nest has touch with past experience as no reflex ever had. That it has 'past' and 'future' implies its having 'now'; not conceptually, but all three as factors influencing action. Such consistency in sequences of situations as is shown by our dog when we call him from the road, or yet more when the sheep-dog collects the scattered flock from the hill-side, lies beyond all reflex accomplishment. That impression of unity which normally our dog gives us rests in part on this consistency of his acts. By it we learn to know him as a friend. The joyous bark, greeting us even from a distance, the gambols and the wagged tail that herald the daily walk, the quiet snuggle which asks for peace after a scolding. Reflex action supplies none of these. Yet without this how different dog-behaviour. The reflex supplies no 'behaviour' hinting at 'values'. As Goethe said when he read the book, new in his time, called *Man a Machine*, "what a Cimmerian grey!"

A purely reflex pet would please little even the fondest of us; indeed the fondest least.

In its application by the physician dealing with the nervous system of man, reflex action has proved just an extension of Willis' category of acts elicitable mechanistically outside will and even consciousness. It has not furnished any general endorsement of Descartes' position that man, 'will' and 'reason' apart, is simply a reflex automaton. Before medicine as a science could give any general endorsement to that Robot-view of man it would have to ask more exactly what 'will' is. Where in regard to motor acts do we draw our line between 'will' and not 'will'? Descartes perhaps cut Gordian knots with a slash.

Spinoza at the time criticized the Cartesian position. He saw the problem in a light essentially more modern. "There is in the mind", he said,* "no absolute faculty of willing or not willing but only particular volitions like this or that affirmation or this or that negation. Will and understanding are one and the same thing. Ideas are not dumb figures traced on a canvas; the assumption that they are is what prevents our seeing that every idea inasmuch as it is an idea contains affirmation or negation. There is not in the mind a will absolute and free; but the mind is so conditioned as to be caused to will this or that, by some cause which is determined by another cause, and this by another and so to infinity.† So then the relation of the understanding and the will to this or that idea, to this or that volition, is that of stoniness to this or that stone, or that of humanness to Peter or to Paul. Will cannot be called a 'free cause', but only a 'necessary cause'.‡ The will is nothing else than a manner of thinking just as is the understanding. Men think themselves free, because they are conscious of their volitions and of their desires and are oblivious to the causes which dispose them to desire and to will."§

Perhaps to this a comment, wholly without cynicism, might be that, from the human standpoint, the important thing is less that man's will should be free than that man should think that it is free. That can indeed serve to activate and sustain his

* *Ethica*, ii, prop. 49.
† *Ibid.* prop. 48.
‡ *Ibid.* prop. 32.
§ *Ibid.* appendix.

zest-for-life. This last, if he have it not, assuredly he is a biological failure and will cease to be.

What do we find is our position then? Some of our motor acts appear to be from start to finish, affairs of relatively simple physical and chemical reaction. Are all our acts of that same nature? Are those main acts so, which in their sequence one at a time occupy our waking day? Those acts which if we look back on our day count with us as what for that day we have done. Mind certainly went with them. If we regard them as reflex, then the whole of our behaviour is reflex. Such use of the term reflex makes it simply synonymous with the determinate of determinism. If so, let it be so recognized. But these acts are not what physiology classes as reflex. Neither is a habit, however habituated.

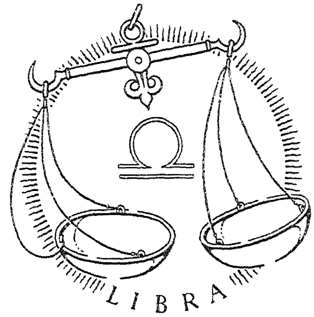
To subsume the whole of human behaviour under what has been called 'reflexology' might further be taken to mean that the roof-organ of the brain reacts simply on the reflex plan. But that there is much which contradicts. Our inference has to be that we are partly reflex and partly not.

As to the mind and brain one supposition is that mental experience running with the physical act, though wholly disparate from all material events and therefore from the physical act, the two series of events, mental and energetic, yet somehow keep step together, their doing so being evidence that they are related, but with no suggestion as to 'how'. As Bergson insists, to speak of parallelism between the two is hardly allowable because they are incomparable. There remains yet further the non-possumus inference that mind is an epiphenomenon, and that the mental and physical do not interact.

It may be, although we do not know 'how', that mind does influence energy, and so does share in the management of the body. Such an assumption was easier made when the notion of matter or energy was less definite than it has latterly become. The pragmatic position which, while silent as to how mind can affect matter, assumes that it does so, is somewhat as though agnosticism should believe, even in the field in which it declares it has no knowledge, much as we do, according to Pareto, in the affairs of everyday life.

The view that the mind has power over the motor doings of its individual, offered no difficulty to our friend Fernel in the sixteenth century. His finding, as philosopher-physician, was that the rational mind was a heavenly inmate of the body, and guided it as the mariner his boat.

To attach mind to energy would have been thought at one time to make all human behaviour perforce part of a necessitarian scheme of things; part of a Laplace Universe. Today the physicist releases the individual in that scheme from necessity. The individual becomes part of a probability system. In that system the biological advantage which mind seems to confer on the concrete individual is improvement and control of the motor act. It seems to attach only to such doings as can be modified. It attaches to them most when they are most modifiable It clinches Carlyle's aphorism that "the aim of life is an action not a thought". The influence of mind on the doings of life makes mind an effective contribution to life. We can seize then how it is that mind counts and has counted That it has been evolved seems to assure us that it has counted. How it has counted would seem to be that the finite mind has influenced its individual's 'doing'. Lloyd Morgan, the biologist, urged that "the primary aim, object and purpose of consciousness is control". Dame Nature seems to have taken the like view.



VII

THE BRAIN AND ITS WORK

The chief function of the central nervous system is to send messages to the muscles which will make the body move effectively as a whole.

E. D. ADRIAN, *The Mechanism of Nervous Action.*

L'homme n'est qu'un roseau le plus faible de la nature; mais c'est un roseau pensant.

PASCAL.

VII

BIOLOGY analyses the organism in the instance of ourselves and many others like us into an assemblage of quasi-independent minuter living units. It clinches that finding by showing that each of us for a short time lives as one such single unit. Physical science, with its units of a different order, carrying out on us search for its units finds that they likewise make us up. It finds us like the rest of what it has examined, a mass entirely resoluble into units of what it calls 'energy'. Of all that a compound organism, such as one of ourselves, does, the greater part is satisfactorily traceable by biological analysis to the properties of the component biological units, in this case the 'cells' of the composite individual. So, similarly, under physical analysis, item after item of the behaviour of the whole is resoluble into behaviour of the subvisible physical units. These latter our fancy can perhaps think of ultimately as electrically charged 'packets of motion'.

There remains however among the happenings met with in such a compound organism as ourselves and our like a certain residue seemingly not thus resoluble. Neither by the biologist with his analysis, nor, and even more definitely negatively, by the physicist with his analysis.

The residual phenomena left unaccounted for by each of these analyses are the same. Since they are phenomena which seem all of one category, we may class them together. They come then under the one word 'mind'. Energy acts, *i.e.* is motion. Of mind a difficulty is to know whether it is motion.

Among the phenomena of life, mind is one which, as we were noting, seems of more restricted distribution than at one time was currently supposed. But in so saying we use 'mind' in the meaning 'recognizable mind'. Mind as in everyday parlance we understand it. Mind presupposing of it what each of us experiences as 'mind', feeling, knowing, wishing and so on.

Mind, even admitting those grades of it which are only with difficulty decipherable, seems still a phenomenon more restricted in distribution than is life itself. Both in time and space there seems a surplus of life without it. In the sense of recognizable mind, it seems a relatively novel terrestrial fact.

At first approach we might have thought, and some did think, that the integration of the individual, the making of such an individual as one of ourselves, or for that matter of our friend the dog, is a synthesis by mind. But the evidence is against that; it is the integration of the individual which brings with it the finite mind. We may ask what part of all the action, of which the individual is the scene, does its mind go with? Of all those other phenomena which biological and physical analysis successfully trace to origin in their respective units—those other phenomena which come under energetics—which of them all does mind consort with? The answer is not in doubt. Those of the nervous system. And primarily which of the nervous system? Certain motor acts. In the great array of motor acts done by animate things there is one class of act which differs in no wise from others except that for its time being it, so to say, grips the individual as a whole, and nothing else going on in the individual may impede it. It is this one main doing which has an accompaniment of mind. As it gives way to the next main act the mind, so to say, leaves it and accompanies that next one.

Nor is that accompaniment spread over even the whole motor act. To dip my pen in the ink may take my mind for the moment with that item of action, and leave so to say none with all the rest of me in what that rest is doing elsewhere. Does its accompaniment by mind improve or help or perfect the motor act in any way? One thing it would seem to do is to add a temporal relation to it. It seems to relate it to the future—the immediate future. It imbues it with purpose. The act puts forth as it were a little bud into futurity. Then also there is lent to it a something of the past. Perhaps explicit remembrance of a former act. The motor act is set as between a future and a past. It gets temporal relations; also it gets space-relations. A 'whereness' attaches to the ink, and to the pen which goes thither to be filled. They have a place in an orientated scheme of space which is part of my experience. The act is set within a system of space attaching to the 'I', which last regards itself as the doer of the act.

This is all obvious enough, and trite. But it contradicts the statement we set out with a moment ago. There was a residue which physics and biological science could make nothing of. We are now supposing that insoluble residue can dissolve in the ordinary doings of the body. Mind is not demonstrable as energy; and conversely energy is certainly not demonstrable as mind. Can mind have leverage upon the motor acts of the body, or upon the 'motor individual', as we called it, which is energy of the body in commerce with that of the surround? Physical analysis resolves that individual into rushing electric charges. No one has yet attached mind to them, nor does there seem approach to doing so. That the individual should have mental behaviour remains therefore under that analysis an enigma.

To some of our acts there attaches mind; to other of our acts there does not. Can we decipher the ground of that discrimination? There is a homely instance which seems to offer something of a clue. The taking a morsel of food is an act presenting successive phases. An initial phase deals with the morsel in the mouth. During that phase there is a finely regulable moving of the morsel about, moistening it, and so on. This involves co-operation between the lips, the tongue, the teeth. The morsel and what is being done to it are then present to the mind; the mind's 'attention' can be turned to it. If it be a delicacy perhaps acutely so. We can manœuvre it with the mouth a longer or shorter time. We can hurry or delay. We can, if for instance the morsel be unpleasant, reject it. So long as the morsel is within grip of this phase, and is experienced by the mind, our motor act in regard to it remains, we find, open to modification; it would seem, at 'will'. Finally this phase of the act culminates by directing the morsel from the mouth into the grip of the next phase, the 'swallow'.

The morsel passes over into charge of an act effective enough for its relatively simple purpose, namely to sweep the morsel into the interior of the body. With that transit the morsel becomes forthwith lost to the mind; lost except that recollection may recall it as part of a past situation. Not that muscles and nerves are no longer engaged upon it. They have much further active commerce with it. The mind however has no contact with them or it. And no effort of the integrated individual can now delay or hasten or modify in any way the treatment of the morsel. The individual *per se* cannot, even if the morsel be poison, control further the dealing with it. In short, where the act of the integrated individual can do no more about it, mind forsakes the act. Our inference would be that one use of mind in the individual is to control and modify the individual's motor act.

The finite mind appears to be an outcome of the integration of the individual. Not, however, of integration merely in general. It seems the concomitant of one only of the several kinds of integrative processes combining the individual's whole. Thus, the heart with its tubular system, pouring nutriment into every nook and corner of the living body, is an integrating mechanism and of supreme importance. If it stop for a minute or so our life stops. The highest integrations by the nervous system are not so urgently important as is it. But mind is not in any way the maker or the outcome or accompaniment of the blood-system integration *per se*.

Even portions of the individual are up to a point integrated things. That holds for what gross anatomy recognizes as 'organs' of the body. Each of these organs is a co-operative assembly of units which forms an integral machine or perhaps better said, since often what they do is chemical, an integral factory. Thus, with the kidney the cells in some of its parts engage in separating substances from the blood, those in other of its parts in returning certain of those substances to the blood. Between such opposed processes there obviously cannot be much in the way of *ad hoc* mechanism in common. The vital thing is the net result. That requires in quality and quantity a delicate adjustment to the circumstances of the body and on the part of one set of cells a sensitive adjustment to the other. This co-operation is attained with a precision and range, which leave a student of the subject astonished by its efficiency. The efficiency turns, so to say, on a complete 'understanding' between the cells which working on one principle remove things from the blood in right kind and quantity as the moment requires and the other cells at another part of the kidney which working on another principle restore in due amount and kind to the blood some of what has been taken from it. Each cell in these two classes is a little self-centred life; yet what it does is co-ordinated, by means whose exact nature is as yet not fully known to us, with the doing of all the other cells which along with it compose the organ. They arrive, as Dr Ekehorn* has recently insisted, at an integrated organ; but an integration in which mind plays no part.

From such integrated organs the organism itself in its turn is integrated. Besides their self-regulation they regulate each other. The lung by regulating in *one* respect the composition of the blood regulates its own activity. But for the lungs to function properly the kidney must regulate in other respects the composition of the blood. For the kidney to do this the pituitary gland in the head must duly secrete its contribution into the blood. A healthy man is a set of organs of interlocking action regulating each other, the whole making a self-regulating system. It is practically a chemical system, and its means of interaction between organs is largely chemical. This partnership of the organs is worked greatly by secretion within the body of special chemical substances. It is somewhat as though in order to intensify a muscular act when required, the body injected itself with a dose of strychnine, or as if to allay pain injected itself with a narcotic. Internally secreted substances distributed by the circulation co-ordinate the work of different organs and bring them into co-operative union. They, in a sense, integrate the many-organed creature, or body, into one working chemical organization. But they have little hand in, and have had little hand in, that integration whose outcome is mind.

We cannot imagine an animal integrated by those other means ever attaining through them an integration to which mind would accrue. Their direction is not the direction in which mind lies. They would make a mechanism doing a number of things but it would not have mind. The kinds of functions which such chemical integration could compass are incidentally illustrated by the growth of the embryo. Chemistry builds. All of that impressive growth and development which produces a child from an egg-cell is in the main chemical building, operated, regulated, co-ordinated and unified chemically. The new-born infant may indeed be said to be a product of chemical integration. But, as

* *Über die Integrative Natur d. Normalen Harnbildung*, Helsinki, 1938.

the event shows, integration there does not compass mind, except in potentiality. Our sixteenth-century Fernel would say it constructs a tenement for mind but—and that he would have found natural enough—it does not produce the tenant. What we have seen establishes that the integration of the body is not the work of its finite mind. Much of that integration lies altogether outside touch with the mind. On the other hand the integration of the body in virtue of one of its features brings with it, if we take the facts at their face value, mind—recognizable mind.

The motor acts of the individual require co-adjustment of a swiftness and spatial precision not needed elsewhere. It is such integration of 'doing' which has, for one thing, to compass the securing of food. Quest for food is one attribute of the zest-for-life. Much of the food is quickly moving food to secure which requires a certain minimal speed of movement. Speed also serves as means of escape from being food for other motor things. There is a competition between securing and avoiding capture. Moreover the spatially precise will secure capture or avoid capture where the spatially clumsy will fail. Chemical integration by means of chemical messengers is excellent for 'digestion' or 'growth', but supplies no co-ordination quick enough for these 'acts of external relation' as physiologists were wont conveniently to call them. For these their speed, precision and quantitative grading demand another mode of integration. The nervous system supplies it. As M. Bergson picturesquely says "there is a struggle of the body towards unity, in which the brain plays an indispensable part".*

Integration by the nervous system is *sui generis*. Static unity is conferred on the body largely by means of intercellular material—the connective tissues, some actually solid as in bone. Chemical solidarity is secured by transference of material in mass within the body, as by the circulation. But integration by the nervous system is worked by living lines of stationary cells along which run brief electrical potentials which, at certain places, excite or repress others. Finally, reaching muscle they activate it. It is not surprising that this integration has the features of speed, nicety and gradation. We sometimes call these electrical potentials 'messages', but we have then to bear in

* *Evolution Créatrice*, p. 209.

mind that they are not messages in the sense of organized symbols. To call them 'signals' presupposes an interpreter, but there is nothing to read 'signals' any more than 'messages'. The signals travel by simply disturbing electrically the next piece of their route. All is purely mechanical. As mechanized as is a relay-switch, or the release of a spring-hammer which then releases another and that a next, and finally a stronger spring which instead of being a bell is a muscle. To call the nerve-potential a signal is rather to read our mental selves into a picture about which our very difficulty is that we do not find our mental self anywhere in it, since it is nothing but physical mechanism.

We see that this may consort well with Descartes' automaton. Instead of clock-wheels and weights, relays of electrical potentials running along nerve-paths, to fire off finally these muscles and not those or those muscles and not these. The automaton figure moves this way or that way in result. Which muscles are worked will be settled from the start, because some starting-points lead to some muscles, others to others.

Where are the starting-points? they are scattered about the body, some within the body, most of them on its surface. The outer surface of the body is that on which the great world, the macrocosm of our sixteenth-century Fernel, plays. It is that surface which feels, and has felt for countless ages, numberless vicissitudes of the environment. It is a surface sown with points which transact business with the outside world. Some react to one kind of external happening, others to other kinds. The points are in so far selective. They are the starting-points for the travelling potentials of the nervous system. They thus through the nervous system have at their call the muscles of the animal, and therefore its movements, its motor acts. They play on the motor machinery of the animal. They play little on the great chemical reservoirs or factories, nor on the static structures; the nerve-paths do not lead thither. The nerve-paths lead directly or indirectly to the motor machinery. With it they make the animal do this or that. The motor individual judged by this contrivance would seem a puppet in their hands, a Descartes' automaton driven by the external world, just as those "garden-figures driven by springs of water".

The mechanism is purely physical, but is not so rigid as Descartes' wheels, weights, etc. It is a network of nerve-paths, composed of branching nerve-cells, and the contact-points between the cells are nodes in the network, and these nodes introduce variability of reaction. Each is the junction-point between two semi-independent variables, each separably affected by activity, fatigue, etc. Function fluctuates therefore at these junctions more than elsewhere. They are called synapses.

In virtue of the layout and of automatic checks temporarily blocking or freeing its nodal-points, the different bits of the automaton move in relation one with another. When one eye turns to the left, the other does so and the neck too; the automaton 'gazes to the left'. Or, as when the dog runs, the diagonal limbs swing forward while the other diagonal pair push backward and prop and propel its weight. In short, nerve unifies the motor animal and gives it solidarity.

But we were promised mind. Between reflex action and mind there seems actual opposition. Reflex action and mind seem almost mutually exclusive. In short, the more reflex the reflex, the less does mind accompany it.

The knee-jerk is reflex. Mind does not accompany it. To ask 'why' is perhaps an impertinence. Yet, if we dare—when a reaction is inevitable, is there anything for mind to do about it? What is there to interest mind in a situation in which mind cannot count? A physical movement which runs up one nerve-thread and down another; in result, a momentary straightening of the knee, which in and of itself serves no purpose, a negligible fragment of a more general purposive movement. We saw mind does not know the 'how' of the act; what it concerns itself with is the 'why'. What is there here then either to interest it or to demand it?

Such a reflex movement, taken by itself, is equivocal of purpose; it can enter as a fraction into various reflex acts of wholly different purpose. It is a fragment of an act, not an act. It is a feature which can become a picture only when it has with it other features. An act, from the point of view of *mind*, is a doing with a definite aim. It is integrated from parts and some stand nearer to the aim than others. If I have under the microscope an object which I want a friend to see, my hands move the preparation to bring the tiny object into the centre of the microscopic field of view. I am seated; my head is stooped, one of my eyes is looking through the microscope-tube, my other is, by practice, sufficiently detached from the other's act to be not convergent with it, and I am unaware for the time being that it sees anything. The fingers of both my hands are tentatively pushing the glass-slide slightly this way and that, with the 'purpose' to move the object to the desired spot. I would regard the search with my fingers as the focal part of the integrated act. The sitting, the stooping, the looking, although parts of the act do not dominate it as does the search by the fingers. The rest is background. It is to the focal act with the fingers that mind particularly attaches. Not to the fingers as such, still less to the executant mechanism moving them, which is away up the arm. What the mind is concerned with is not the act but the aim. It is more aware of the finger-part than of the rest because the fingers' part stands nearest to the aim. The rest is mental fringe, even submental. Finite mind is like a moving focal point which wanders restrictedly within each of us, with an aim. Never at any time pervading much of us. At all times most of us is impenetrable to it. Clearly we must not suppose 'life' and 'mind' are one and the same. The finite life is a phenomenon accessible to sense; the finite mind is not.

We have but to look round in the great ocean of animal life to see countless instances of the motor act going forward without recognizable mind. The nervous system is still its means. Countless instances where, as in our own knee-jerk or contraction of the pupil to light, the motor act is mindless. Countless instances further where the whole active creature is in the above sense mindless and is so at all times. Such a creature's nervous system runs across it from surface to muscle, a tie between a trigger-organ pulled by the external world and the muscular coiled spring which the nerve-impulse releases. In the glass-clear, often lovely, creature Medusa, the muscle is a pulsating swimming bell. Its trigger-organs, whence the nerve-threads pass, are called 'ears' and 'eyes'. The misnomer must not lead us to think them sense-organs. As traced upwards in the ascending series of living forms, they may become so. In our own stock it is partly so. The trigger-organ remains what primordially it was, a means of releasing a motor act; but it gets secondary connections with the nerve-lines from other trigger-organs doing likewise. It is the coming together of these secondary nerve-lines, their inter-action, the setting up of a clearing house dealing with transmitted signals and transmitting them to muscle, in short the organizing an integrated motor act, which constitutes the earliest habitation, as Fernel would have said, of mind. The integrated motor act even when lowly contains earnest of mind. Hence comes about the germ of our brain, which we may think carries implication of our mind.

The brain arises as a rudimentary side-growth from a power-path. A side-growth which, meeting other paths, will enable other paths to share in the control of that power-path, and enable that path to share in the control with those others. An organ of co-ordination of motor acts. A means of integration of the motor individual. A nervous organ which will grow until it far outweighs all the old nervous motor machinery taken together. It is because that organ becomes a 'place of mind' that the trigger-organ leading to it then becomes a sense-organ. It is still a trigger-organ but to pull the trigger, besides bringing about the release or the checking of a motor act, brings about a reaction of the mind. The motor individual as represented by its nervous system is never at rest and the effect of the trigger-organ is to impress some change in an activity already in process. So the mental individual is never at rest and the effect of the trigger-organ is to impress some change there on activity already in process.

Mind, recognizable mind, seems to have arisen in connection with the motor act. Where motor integration progressed and where motor behaviour progressively evolved, mind progressively evolved. That kind of motor integration which arrives at concentrating the complex mechanism on doing one thing at a time offers a situation for mind; and the doing of that one thing finds mind alongside it. But not the whole of the doing. The integrated act has its focus, and there mentality has its focus.

At its beginning, mind, this individual mind, which we imagine germinating in the primitive animal as an appurtenance to motricity, can we imagine what it at first was like? Evolution brought it; natural selection sanctioned it; it had survival value. What was it like? Doubtless we have no word which can fit it. Language never had acquaintance with it. Nor has our experience now. Yet from it, we may think, sprang as from one common germ the several types of mental experience which we have; conation, affect, perception and the subconscious which escapes all words because it is subconscious.

If we think this then we may feel it not futile, not without some possible gain of perspective, to ask of probability what it may conjecture was a starting-point for this mind, which has developed along with the development of life. The story of that kind of matter which is spoken of as living matter is a story of a perpetual encroachment by a chemical system of new type on other chemical systems spoken of as lifeless. Life has been called a disease of worn-out matter. Whether a disease or no it is something which has certainly spread. Our planet produced it we must suppose from lifeless matter so called; the living matter produced has never ceased to extend itself by incorporating more matter, though that again reverts to lifeless. Continually to grow at the expense of other matter seems of the very essence of its scheme. It extends the system which is itself. Inherent in it is to increase. It is doomed to grow, including under growth that form of increase termed 'reproduction'. If its physico-chemical system dooms it to increase, replenishment is the physico-chemical corollary. We observe the living thing and we see this going on. This is its 'behaviour'. It is under pressure from itself to 'seek' food, to 'avoid' death, to 'multiply'.

Pressure is put upon it by itself. 'It has an itch to live.' This itch is universal with it. Under the microscope it gives us a busy scene. Minute lives hurrying hither, thither, feeding, jostling. Driven, each says almost as clearly as if it spoke, by 'urge-to-live'. The one key-phrase to the whole bustling scene seems 'urge-to-live'. We hesitate to read into that 'urge' of microscopic beings more than physico-chemical behaviour. The scene becomes then a physico-chemical situation with physico-chemical reactions feeding and increasing life. Is there in it or with it over and above that a mental urge as well? A 'zest-to-live'?

If, from the microscope, we turn to look at the busy street, with its individuals hurrying hither and thither, hastening to earn, entering restaurants, is there no resemblance to that other, the microscopic scene? What phrase again sums it up? So far as one phrase can, 'urge-to-live'. And here, because we know it in ourselves, we can read securely into that urge, as of it and with it, an element 'zeal-to-live', 'zest-to-live'. The physico-chemical has here its mental adjunct. Life's zest to live as outcome of life's tendency to increase in bulk. Long the stretch of distance between that microscopic population and this human one. Yet if a form of mind there be in that microscopic population, though as a germ so remote that no word of ours can duly fit it, is it not probable that that mind is 'zest-to-live' in germ?

A ground assumption with Fernel was that man, linked to the rest of animate nature in so many ways, in one respect breaks wholly from it. His alone are reason and free-will. Fernel seems to fail to notice that these are still harnessed to 'zest-to-live'. They are just in the same case as are all the other degrees and aspects of mind. Man is by reason of them still as much as ever one with all the rest of life; indeed he is by reason of them more deeply pledged to the common purpose, or branded of the common stock, than is any other. For Fernel man has a whole category of the soul which nothing else earthly has. By that right he is in truth *not* of the earth. It seems to escape Fernel that man's life of all lives is the most completely and fully bound to earth because life's experience, wholly earthly as it is, is in man's case the most complete and full. Being the completest of its kind, and its kind being that of the planet's side, it is more thoroughly earthly than is any other. And it is subordinated to 'zest-to-live' as an aim. It is the most complete and full nexus between life and earth that we know. Man is the most, not the least, earthly of all creatures. His knowledge, feeling, strivings all conspire with his body to make him so to a degree unknown to other life. When Fernel minimizes the tie between earth and man as one of merely a passing human sojourn here, he repels us therefore as submitting a strange and inappreciative gloss upon a transcendent situation. To Fernel looking round at his animal kith and kin this misreading of his situation colours his view of them, his interpretation of them, and his bearing toward them. They are no kith and kin of his. They bring no message to him about himself except that they are for his use. So even in the late eighteenth century (1786), with Kant* in his 'human history'. There man addresses the sheep; "that coat you wear Nature did not give to you but to me"; and he strips the sheep and clothes himself. Kant stresses that man from the very beginning "understood his right to hold all creatures as means and tools given to his will for the attainment of what he may intend". Kant in this might be Fernel speaking 250 years before. With him too animal kind was simply food for man's body, draught for his plough, fur for his warmth, remedies for his ailments. From all he has to say about creature-kind we may think Fernel's view would run, "they are not evil in themselves; though powers of evil may use them". Yet Fernel was judged a man full of sympathy and compassion.†

New knowledge has put our creature-kind in a new perspective for us. They are in a sense drawn greatly closer to us. They are not now another order of being. They are our kith and kin. Their nature and ours are one. They are each and all impelled as are we by the same 'urge-to-live'. We and they are all comrades in one same great adventure—life. They and we are striving toward the same goal. All of us were launched and are steered by one same 'urge-to-live'. For me to know that is for me to see the animalcule set for the same end as I am. It gives me a basis for understanding other life along with mine. As I ask the meaning of the world of life it gives me a 'wherefore' the nearest to a universal that I have ever got. Speaking of the 'self' Charles Myers says, "the psychologist's principle of the conservation of self, which corresponds to the biologist's inevitable principle of the struggle for existence, is the fundamental function of this conscious activity".‡

Surely it furnishes too a bond of sympathy between all life, namely, that in the same world we all have the same aim. With each life in its own thinking, so far as it have thought, its living is what the world is for; its own life is its first charge on the world; where it *has* mind, that mind endorses the view. Thus each life is a harmony of acts attuned to zest-to-

* *Sammtl. Werke*, iv, 341 (Hartenstein).

† See Plancy's *Life*. ‡ *Realm of Mind*, p. 251.

live. Should that make life a sacred thing as between lives having the 'values'?

It might seem so. But the world of life shows another picture. Is life sacred? Life conflicts with life, even to the death. Life feeds on life. Man's own life feeds upon other lives. Life finds its direst enemy, the planet over, is other life. In the world-order, at least as instanced by our planet, life is not sacred. What is life? Life *per se* we have taken to be an affair of certain self-fermenting proteins catalyzing their own growth. What is there sacred in that? But life, always itself a finite 'thing', has in many instances attached to it recognizably finite mind. Does that attribute make life sacred? It is a property with grades of quality and trend. It would seem, the human mind, cohabiting the planet with these other minds, if it is to exploit the planet must in the light of its 'values' take the responsibility of judging the grades of sanctity of these other minds. Is life a 'value'? Surely a means to 'value'. Is life then sacred? This life conflicting with life even to the death? And there are grades of life. The question would seem not whether life is sacred, but how far sacred. That question looms as one likely to grow a sterner and sterner problem. A question which we may think the future of this planet turns upon. A part of it is this, whether the planet in its approaching phase is or is not to be *the human planet*. An approaching phase where all life on the planet shall be subordinated to one life, human life. That one life, human life, seems on its way to something, natural truly, but nevertheless super-human. What means shall bring it about? Mind serving 'zest-to-live'? How? By ruthless conquest or beneficent mission. As to which, it lies with the 'values' to decide.

As for an actual connection between the brute's soul and his own, such a thought finds no place in Fernel. It may well have been unthinkable to him. It is not so today. Today with the old line of absolute division broken down we remember that even our poor relations, the fish and amphibian, can 'learn'. The dog can learn more quickly and more variously. The child more quickly and more variously still. Is the child's learning something wholly dissimilar from those others? The child learns by concepts. Is that a difference more than of degree?

Did conceptual thinking come to the human mind *de novo* and fully fledged, a new gift? Or did it come climbing the sub-human ladder? The man-like ape clearly has symbolic thinking.* It has 'thatness' as well as 'thereness'. What is the conceptual in rudiment? Has the dog no such rudiment? With such queries we may do well to carry ourselves back in thought to man in his primeval setting; man shaping a stone into a tool. What of the pre-human and sub-human chapter preceding the notion 'tool'? The chimpanzee is a tool-user and tool-deviser. He will, untaught, take a crooked stick to bring a banana within reach. Where one stick is not long enough he will, untaught, join together two end on for the purpose. May we not think his experience has brought to him some adumbration of 'tool' as a concept? Would not the sub-human and pre-human record if we had it lead us along degrees of mind which link us without break to frankly infra-human ways of thought, to brute mind whence human mind has come? When our dog stops tip-toe with lifted head awaiting the strange dog, are we to suppose he has no general notion of 'strange dog'? When he sidles to us with half-averted face and asks a word of praise or notice from us, is he not self-conscious? For Fernel man's mind was another order of mind created by heaven and placed above the rest. For us man's mind is a recent product of our planet's side, produced from mind already there long previously, yielding man's mind by gradual change of previous mind.

Our roof-brain is the latest, and crowning, organ of our nervous system. It is debated whether the way in which the roof-brain acts is or is not reflex. The difference is more than merely what shall be 'called' reflex action. The question is whether and how to account for human behaviour by an arrangement of nervous through-lines disposed somewhat after the manner of the switchboard of an automatic telephone-exchange.

One difficulty held to exist for explanation by reflex action is that behaviour by the roof-brain presents immense variability from occasion to occasion. Even under seemingly similar impulsion the result baffles particular prediction. Can reflex action

* Robt. M. Yerkes and H. W. Nissen; Yale Univ. Lab. of Primate Biology. *Science*, 23 June, 1938.

compass such variability? Reflex action in simple examples has relative fixity of outcome. The very simple reflex has something the character of a penny-in-the-slot machine. The coin inserted evokes invariably the expected ticket. But with more complex reflexes that monotony does not hold. There is a great gap between the reflex conditions circumstancing the knee-jerk and the reflex conditions we must assume circumstancing 'choice' of a book from the bookshelf—supposing the latter reflex. I have the conviction that I can pick from the bookcase either this book or another. As I do not however know which of them determinism prescribes I cannot of course tell whether in taking a volume I depart from determinism or do not depart from it.

Then too the reflex result varies with different nervous states. With a spinal reflex a given stimulus which when the limb is folded thrusts the foot down, when the limb is straight will draw the foot up. The stimulus is the same, the nervous machinery is the same, but the internal setting of the nervous machinery is in part conditioned by the posture of the limb at the time. If we carry this over to the vastly greater complexities of the roof-brain, capable as it is of being influenced by the remotest visible star, the wonder perhaps is that, be it as reflex as it may, surrounded by the changeful waking world, the same stimulus on two separate occasions ever evokes the like result.

Supposing the roof-brain to work reflexly, would that exclude its meeting situations with adjusted variety of response? Its conduction paths are many more than million-fold. Admitting them to be, as if reflex they would be, each but a 'one-way' street, even then, with their myriads of cross-connections and adjustably-valved junctions, they could permit a variety of pattern of through-traffic almost unthinkable. Millions of valved junctions under opposed processes which sum or cancel so that at each one of them any grade of freedom obtains between full width and closure.

As a system it is open to the simultaneous play of two worlds which act upon it overlappingly, the body itself and the world around the body. Through it these two react upon each other. The changeful patterns of both worlds engage the end-points of the system in sequences of patterns. The reactions spread and combine and conflict; always with significant result, because the incompatible extinguishes itself. The total upshot, where it overflows from the system as a motor act, does always something meaningful.

We can think of it as Fernel thought of Aristotelian 'form'; always a harmony, but not a harmony built out of parts in the sense of merely a product of harmonious parts. It itself is the cause of the harmony of its parts.

Add to this a further complication, especially stressed by Pavlov in his studies of habit-formation. The previous history of the individual activity partly settles what it will lend itself to. It establishes 'habits' of reaction; and such habits, owing to different individual histories, will from individual to individual differ.

It seems plain, were the machine merely reflex, its complexity and individuality would make its behaviour to the shifting situation of the moment variable beyond all prediction other than statistical. Strangely enough, to the reacting individual himself his behaviour normally occasions no surprise. Stranger still, of all people the reacting individual himself is the last to think himself reflex. Such a reflex system, operated by sequences of thousand-patterned stimuli corresponding with total situations of the moment, might well work a Robot for many purposes indistinguishably from a man.

Such a Robot would be able to adjust itself to infractions of its own machinery. Our nervous system reaccommodates itself after injury. The injured nerve mends itself and can resuit itself to disabilities. A chain of nerve-centres in linked action has always a 'leader'. That 'leader' lost, the leadership passes automatically to another member of the chain. In the crab with a claw caught in a cranny, the local nerve-centre breaks that claw off and the others under their local nerve-centres resume co-ordinately the interrupted promenade. That is worked by simple reflex action. In the heart, which is simpler still, if the primary starting point for the beat gives out, another point nearby takes on the lead.

Last century discovered that the roof-brain was not, as had until then been thought, 'equipotential' throughout. It had been thought of as doing just the same kind of thing in all its parts, although what kind of thing that was had remained a mystery. Then different fields of it were found to execute different bits of behaviour. The notion sprang up that with this or that act went activity of this or that of the roof-brain's several surface areas. Outside such an area the rest of the field seemed indifferent for the particular act in question. The act was said to be 'localized' in the roof-brain at a particular 'centre'. This view gravely mistook the scale of collaboration of action within the brain. Recently, perhaps in revulsion, the opposite kind of view is pressed. It is urged as doctrine that "every excitation arising at any point whatsoever of the central nervous system affects the whole system" (Bethe). If that means merely that the nervous system is one whole and that with a change at any point of it the whole is in so far not the same, it is of course true but seems too obvious to require statement. If it however mean that excitation of the system at any point affects it throughout, then the statement exceeds what observation discovers or finds likely. Part of the delicacy and efficiency of the system lies in its provision for the reaction of one set of factors not necessarily to disturb the reaction at the moment of certain others. There is ability on the part of the system to limit a disturbance within it. The marksman's gaze following 'the bird' is not upset by his manœuvring his gun to cover the moving mark. To shift our pose at the desk need not disturb our thought. Our eyelids blink as is their habit without disturbance to our reading.

Electrical technique finds in the roof-brain different fields of reaction even as the microscope reveals there areas of different structure. The activities as electrically observed are not actions which run indifferently over the whole. The activity is patterned, not indifferently diffuse. Excitement even the most violent does not activate the nervous system everywhere, or the whole roof-brain throughout. Such general action would contradict all which the ways and structure of the nervous system tell us about its working. If the function of the nervous system be 'behaviour', diffuse activity would not meet it; it would not produce 'behaviour'. There would ensue chaos, instead of integration. Behaviour is rooted in integration. The patterned nature of the activities of the roof-brain expresses integration by its patterning. That we should expect of it if its working were reflex.

But it is clear that kinds of action other than purely reflex go forward in it. An animal trained to thread a maze might conceivably acquire that facility reflexly. Impairment of the roof-brain impairs the trained acquirement. But within wide limits the particular seat of the structural damage in the roof-brain seems to matter little. Global extent of loss rather than the particular seat of damage seems that which in the roof-brain correlates with the defect in the trained behaviour (Lashley). That could hardly be were the roof-brain purely reflex; a particular configuration of paths would then compel a particular result. Observation indicates rather a roof-brain which overseers subordinate mechanisms, much as a pianist does his keyboard. If he lose the use of one of his ten fingers he may still contrive to play the tune. Even if he have lost the fingers of one hand he may contrive to play. If reduced to two fingers only he will not play so well. When he has lost them all he may not be able to play at all. That is not like reflex action. But the supposed pianist? It will not suffice to suppose him simply a metaphor for 'mass-action'. He has to account for more than can 'mass-action'. He has to account for what a pianist could account for. He has to represent a superaddition of mind to the keyboard. It is not without significance therefore that the roof-organ, the organ which our metaphor took him to represent, is by a dozen different lines of evidence indicated to be—to use metaphor once more—the 'seat of the mind'. But physical science there faces us with the impasse that mind *per se* cannot play the piano—mind *per se* cannot move a finger of a hand.

A feature which belongs to reflex action universally is, that it does not emanate from the 'ego'. Therefore to postulate of man's behaviour that it is wholly reflex is to assert that nothing he does emanates from his 'ego'. Reflex action is action started by a stimulus reaching the nervous system from outside the system itself. Among the cells of the body are a number which activate themselves. Thus, the cells of the heart life-long rhythmically 'self-fire'. Certain nerve-cells are in similar case. For instance, that group which maintains the rhythmic breathing of the chest. They, as a group, 'self-excite'. Electrical technique shows that the cells of some of the roof-brain's successive cell-sheets self-fire. They hold hands and groups of them self-fire together.

The self-firing nerve-cells which work our breathing react in part reflexly as well. Their firing can be hastened or slowed by nerves from elsewhere fired from without. So too with these self-firing nerve-cells of the roof-brain. Their rhythmic self-action is modifiable from without, e.g. by a light in the eye or a noise to the ear. It has recently been found* that if the skin anywhere be touched even lightly there ensues a detectable electrical change in a corresponding spot of the roof-brain. The location of the spot correlates with where the skin is touched. Its responsivity varies cyclically. That is what a cycle of self-activity at the reception station in the brain might be expected to impose on a reflex action going through. If such variables attach to the point of first arrival in the roof-brain, how variable will be the further development of the brain reaction as it proceeds and propagates itself in the huge labyrinth of the brain. One might think two successive similar touches would never feel alike. Commonly they do feel alike, which hints that sense-perception has mysteries still unexplored.

Not so long since, so we have read, science inclined to look upon all nature somewhat as a feat of engineering. That phase passed with the coming of present-day mathematical outlook. A custom of that former phase was for fancy to help itself by recourse to a model. So with our conception of the brain; if we may let our fancy run and follow an engineering bent, it may contrive us something, however crude, not too remote for pictorial service.

A scheme of lines and nodal points, gathered together at one end into a great ravelled knot, the brain, and at the other trailing off to a sort of stalk, the spinal cord. Imagine activity in this shown by little points of light. Of these some stationary flash rhythmically, faster or slower. Others are travelling points, streaming in serial trains at various speeds. The rhythmic stationary lights lie at the nodes. The nodes are both goals whither converge, and junctions whence diverge, the lines of

* Philip Bard, *Bull. New York Acad. Med.* xiv, 585.

travelling lights. The lines and nodes where the lights are, do not remain, taken together, the same even a single moment. There are at any time nodes and lines where lights are not.

Suppose we choose the hour of deep sleep. Then only in some sparse and out of the way places are nodes flashing and trains of light-points running. Such places indicate local activity still in progress. At one such place we can watch the behaviour of a group of lights perhaps a myriad strong. They are pursuing a mystic and recurrent manœuvre as if of some incantational dance. They are superintending the beating of the heart and the state of the arteries so that while we sleep the circulation of the blood is what it should be. The great knotted headpiece of the whole sleeping system lies for the most part dark, and quite especially so the roof-brain. Occasionally at places in it lighted points flash or move but soon subside. Such lighted points and moving trains of lights are mainly far in the outskirts, and wink slowly and travel slowly. At intervals even a gush of sparks wells up and sends a train down the spinal cord, only to fail to arouse it. Where however the stalk joins the headpiece, there goes forward in a limited field a remarkable display. A dense constellation of some thousands of nodal points bursts out every few seconds into a short phase of rhythmical flashing. At first a few lights, then more, increasing in rate and number with a deliberate crescendo to a climax, then to decline and die away. After due pause the efflorescence is repeated. With each such rhythmic outburst goes a discharge of trains of travelling lights along the stalk and out of it altogether into a number of nerve-branches. What is this doing? It manages the taking of our breath the while we sleep.

Should we continue to watch the scheme we should observe after a time an impressive change which suddenly accrues. In the great head-end which has been mostly darkness spring up myriads of twinkling stationary lights and myriads of trains of moving lights of many different directions. It is as though activity from one of those local places which continued restless in the darkened main-mass suddenly spread far and wide and invaded all. The great topmost sheet of the mass, that where hardly a light had twinkled or moved, becomes now a sparkling field of rhythmic flashing points with trains of travelling sparks hurrying hither and thither. The brain is waking and with it the mind is returning. It is as if the Milky Way entered upon some cosmic dance. Swiftly the head-mass becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one; a shifting harmony of subpatterns. Now as the waking body rouses, subpatterns of this great harmony of activity stretch down into the unlit tracks of the stalk-piece of the scheme. Strings of flashing and travelling sparks engage the lengths of it. This means that the body is up and rises to meet its waking day.

Dissolving pattern after dissolving pattern will, the long day through, without remission melt into and succeed each other in this scheme by which for the moment we figure the brain and spinal cord. Especially, and with complexity incredible, in that part which we were thinking of, the roof-brain. Only after day is done will it quiet down, lapse half-way to extinction, and fall again asleep. Then at last, so far at least as the roof-brain, motor acts cease. The brain is released from the waking day and marshals its factors for its motor acts no more.

An act which may seem simple even to banality is the directing of the gaze. Examination of it finds its factors engage the roof-brain far and wide. The 'gaze' and the roof-brain's activity correlate somewhat thus. When we look at an object the eye-ball, grasped by its muscles, is so held that the optical image of what is being looked at lies on the spot of retina where seeing is best. This manœuvre obtains for both eye-balls. It does so not only when we and the thing we gaze at are steady and stationary. It is still managed when the object moves though we do not, or when we move though the object does not, or when both we and object move whether in the same direction or in different directions. In all these cases the eye-balls so move themselves as to keep the image which is being looked at on the best-seeing spot of retina of each eye. To do this requires the combined work of twelve muscles which draw upon the eye-balls along different axes. They have to work nicely, for the best-seeing bit of the retina, which has to be constantly slipped under the image gazed at, is barely 1/30th inch across. This posturing of the eye-balls so as to aim and keep the gaze on a desired point is called 'fixation'. It must not be mistaken for immobility; on the contrary it generally implies continual movement of much accuracy. Nor is it sufficient that the eye-ball be so manœuvred as merely to bring to the place of the optical image the best-seeing bit of retina. That is not enough. It is further required that the centre of that little best-seeing bit be in both eyes brought under one and the same point of the optic image which is being regarded. Unless that is done the object is 'seen double', a dilemma greatly confusing to the mind. The eye-balls' manœuvring succeeds in all this. We watch a bird across the sky whether we stand as we watch it, or whether we are walking, or riding fast in a motor car; and we do so without 'seeing it double'. Our 'fixation' accomplishes this for us. We do it without any true awareness at all of the 'how' of our doing it.

In many animals this act is reflex. In some it cannot involve the roof-brain because practically they have none. In others the roof-brain is not essential to the act, for the act can occur without the roof-brain although a roof-brain there is. In ourselves the act does require the roof-brain. The physician tells us there are instances of nervous disease where the patient cannot command at will the direction of his gaze. Desiring to look at something, he cannot at will turn his gaze thither. "One patient on being asked first turned his head in that direction, then raised it from the pillow, then bent forward and turned his body to the right, advanced his arms, clenched his hands, and groaned that he 'could not do it'."* This might be thought to mean paralysis of the movement. But if asked to follow with his eyes a slowly moving object, his eyes do so. That is, though willed effort fails to produce the act, the eyes follow 'of themselves' a moving point whose image is fixated by them. The eyes remain anchored to that object by the 'fixation-reflex'. Those afflicted with this condition, when they want to look at something fresh, close the eyes for a moment, or toss the head, or place a hand between the eyes and the object fixing their gaze. By breaking the gaze a moment they free themselves from the fixation-reflex; though by willed effort they cannot break it. The fixation-reflex is operated especially from that small central

* Gordon Holmes, *Brit. Med. J.* 1938, ii, 107.

spot of the retina which we called the best-seeing bit. The retinal field around it sees less and less acutely as followed farther from that centre. A main office, so to say, of the outlying part of the retina is, when a fresh image, especially a moving image, plays on it to turn the eye-ball so as to bring the best-seeing bit of the retina under the fresh image. To do this it must first break the already existing fixation-reflex in order to replace it by a new one. Commonly this process, as judged by introspection, seems due to something, to which we are not attending at the moment, calling our 'attention'. Then, by a 'willed' act, we look thither. That is, we break the existing fixation and initiate fixation of something else. In short, the fixation-reflex is normally under 'control by the will'.

Where 'willed' control of the fixation-reflex has been lost, the fixation-reflex lies especially open to observation. By means of it alone, the patient's gaze can still follow the printed lines across a page. The patient reads. "Each succeeding letter, dot, or segment of a line tends to excite a movement" swinging the eyes laterally towards it. This following of each line is done reflexly. The physician finds that the fixation-reflex depends on that region of the roof-brain which he has long judged from various facts to be 'visual'. He finds that 'willed control' of the fixation-reflex depends on a region of the roof-brain widely distant from that where the fixation-reflex runs. Disease can thus dissociate the two factors, the willed and the reflex, which co-operate in us normally. The 'localization' of the one lies at the front pole of the brain, that of the other at the opposite pole. For this relatively simple item of our motor behaviour, the action-pattern in the roof-brain is built up on the co-operation of places in the roof-brain widely apart. The analysis illustrates how one element in this act, although we regard the act as 'conscious' and 'willed', is frankly reflex. We see how what we commonly call 'will' dovetails smoothly in with processes which are reflex.

Not that this analysis brings what is called 'will' as a general entity to one particular place in the roof-brain. The interpretation would rather be that the harmonious pattern of the moment, automatically excluding incompatible elements, derives from the whole situation of the moment, and operates the ocular gaze not purely as a visual reflex. The resolution of such seemingly simple behaviour on the part of the eyes into components so complex and so apart, warns against supposing the roof-brain's action merely reflex.

An unexpected fact about the roof-brain is that the 'five senses' are largely separately identifiable there. Each of them has there a separate primary 'enclave'. The 'organ' as it is called 'of reason, intelligence and will', in a word of those supreme mental syntheses which create and deal with conception and focal act, is found still split up on the basis of the five senses! Aristotle might smile, "you remember what I told you".

This discrete sensual basis for the 'organ of mind' might be thought to promise simplicity. But analysis by the physician of the relatively simple-seeming act we last followed shows that simplicity is not to be expected. Facts rebut the over-simplified conceptions such as ascribe to separate small pieces of the roof-brain, wedged together like a jig-saw puzzle, separate items of highly integrated behaviour. A special place for comprehension of names, a special place for arithmetical calculation, a special place for musical appreciation, and so on.* Such savour of old 'phrenology'. To suppose the roof-brain consists of point to point 'centres' identified each with a particular item of intelligent concrete behaviour is a scheme "over-simplified, and to be abandoned".† Rather, we may think, the contributions which the roof-brain in collaboration with the rest of the brain and spinal cord, makes toward integrated behaviour will, when they are ultimately, as we may hope, analysed, resolve into components for which at present we have no names, having no conception of such processes. To state the organization of the mind in terms of roof-brain activities is a desideratum not in sight. Localized disease or injury of the roof-brain "must expect to find fractionings of behaviour which cannot be expressed or understood in the current psychologic terminology".‡ One fact emerges; in most regions of the roof-brain to produce

* W. Kleist, *Z. Ges. Neurolog. Psychiat.* clviii, 164.

† K. S. Lashley.

‡ K. S. Lashley, "Functional determinants of cerebral localization", *Arch. Neurol. Psychiat.* xxxviii, 386.

detectable mental defect, the spatial extent of injury must be large.

Lashley puts the pertinent question, Can we discover a general significance in the 'localization' in the roof-brain? If so, can we formulate it? A motor act, for instance a movement of the arm to grasp something, has its purpose, it also has its execution. In this latter can be distinguished a succession of component movements for instance at the several joints of the limb, and in each such component movement, the speed, the tension varying with the resistance opposed, the spatial orientation, and so on. It might conceivably be that in the synthesis of this movement by the roof-brain each of these several variables was compassed by a nerve-mechanism separately located. They might there be synthesized into the perfect movement. The serial timing of the successive stages of a movement may mean an arrangement of nerve-cells, different from that required for the movement's spatial orientation. Lashley* brings forward evidence that this suggested radical motive for roof-brain 'localization' seems supported by symptoms consequent on brain-lesions, symptoms which indicate dissociations of function of this kind. It should however I think be remembered that these separable variables (speed, intensity, serial timing, spatial direction, etc.) in the complex of a motor act attach also to movements executed altogether without the roof-brain, e.g. in subcerebral reflexes; and are regulated fairly adequately then. For instance in the walking of the decerebrate creature. One may suppose, recalling that the roof-brain performs its motor acts largely through the agency of subcerebral mechanisms, that it might be enough for it merely to have touch with such already provided regulators of these factors. If not, it would to a large extent be doing their work over again. However, we do know that the roof-brain, with its increasing development in the hierarchy of vertebrate forms, has taken over, for instance in the case of the eye, actions which had belonged to nerve-centres inferior to itself, although those centres are still present along with itself. Thus, the dog can 'see', though imperfectly, without its roof-brain; we without the roof-brain cannot see at all.

Knowledge seems not yet ripe to answer this question put by Lashley. Roof-brain 'localization' however does seem still rooted in the five senses. With the motor act, may it not be that the act's provenance rather than its mechanism of execution is what is mainly traceable in the principle 'localization' in the roof-brain? The processes of thought associated with a motor act then enter more into the picture. Included in the provenance

* *Ibid.* p. 381.

of the act is also thus the aim, Aristotle's 'final cause'. Such 'localization' would take more cognizance of the circumstance that the roof-brain is where 'thought' gets into touch with motor behaviour and the intent of the motor act with the motor act itself.

When our roof-brain acts 'spontaneously', as electrical technique observes it doing, does the intelligible arise? Seeing the continuum of polarized lines which the roof-brain is, an activity arising there should spread as a pattern. Will it correlate with a train of mental action? Poincaré the mathematician told how the solution of a problem came to him suddenly as he stepped into a cab without the problem consciously in mind at all. Kekulé's 'ring-structure' for benzene suddenly 'came to him' outside a London bus!

If the roof-brain acts spontaneously, as electrical technique seems to detect, then there occurs action in it *not* initiated through any gateway of sense. The physiologist uses 'spontaneous' here just as he uses it of the heart, which beats 'of itself', i.e. is self-activated. He does not intend any reference to free-will. If 'free-will' means a series of events in which at some point the succeeding is not conditioned by reaction with the preceding, such an anomaly in the brain's series of events is scientifically unthinkable. When I 'choose' a book from the bookcase I react fundamentally as does my microscopic acquaintance, amoeba, confronted by two or more particles, when it takes one of them. A difference between us is that my fancy conjures up several courses to take. Subsequently I experience my act as doing one of them. That act is, for its time being, my main act. As we saw I am confined to doing at any moment just one main act. From my fancy's plurality of possibles there emerges my *de facto* singleness of act. It leaves me the impression of a decision. Amoeba doubtless is without the fancy; hence without the impression of a decision.

There is an ancient piece of brain, of no great size, which relatively modern parts have outgrown and overgrown. Unlike these latter with the development of cognizing and inferring it has not extended, or but little. Experiment and medical observation show that if it be damaged, still more if it be destroyed, the affective character and motor behaviour of its individual change. That individual's normal activity and affective sympathy are blunted and replaced by stolidity. The individual's motor initiative and emotive reactions are frozen. He has become emotionally unreactive. His facial expression registers no play of feeling. There is torpor and a drowsy state.

When on the contrary electricity is applied to activate this part of the brain, the eyes dilate, the hair bristles, the breathing quickens. The animal bites and claws. In short there is presented a vivid picture of emotional excitement. Or again, when this part of the brain is freed from control of the great overlying roof-brain by removal of the latter the animal becomes emotionally supersensitive. Irritable and excitable, it exhibits, without provocation, fits of rage. All this display of feeling is set aside at once and for always by destruction of this same small region of the brain.

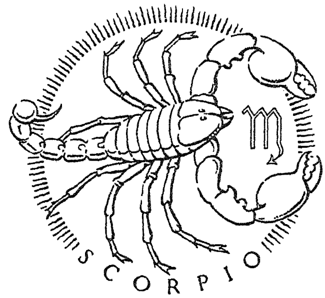
It would seem that to this region pertain the bodily phenomena of affect. Emotion comprises motor behaviour and mental experience, each of its type. As to the former, from this place issue nerve-paths which erect the hairs, dilate the eyes, hurry the pulse, and so forth. Also from it issue nerve-paths up to the great roof-brain, which correlates with mind.

When the roof-brain is gone, the emotional storms generated by this same ancient piece of the brain produce emotional effects which are spoken of as pseudo-affects, for instance 'sham-rage'. Exhibition of 'rage' breaks forth and subsides like a summer shower; it seems mere motor presentment of rage stripped of mental counterpart. That such divorce can be is certain, after yet deeper mutilation. With this focal part of the old brain still active it may be that emotion is back again at something like its primordial essence. A drive, an urge, an added tension; perhaps that is all, but yet a physical reinforcement of its motor act.

To say that this is an ancient piece of the brain is to say that it is part of our brain which still continues that of man's animal ancestral and related stock of long ago. It has meant in them, and still does so, fear, rage and passion; it does so also with man. Doubtless at innumerable turns it has in so doing served them and him well. But over it the roof-brain is a new brain so developed in man as to be the 'human feature'. It stands for knowledge and reason. As we have seen it can govern this old brain of 'affect'. And in man it has developed to be a hundred times the greater of the two. These two in their way epitomize man's complex. Their ratio of evolution in him points significantly. It exhibits the trend of his development. Regarded broadly, the goal toward which animal integration tends, if goal there be, would seem 'mind and more mind', and the immediate meaning of the finite mind in the body would seem to be to influence acts. Its influence upon acts is what, we would think, has given it survival-value.

Then the impasse meets us. The blank of the 'how' of mind's leverage on matter. The inconsequence staggers us. Is it a misunderstanding? Another is not unconnected with it. The universe of energy is we are told running down. It tends fatally toward an equilibrium which shall be final. An equilibrium in which life cannot exist. Yet life is being evolved without pause. Our planet in its surround has evolved it and is evolving it. And with it evolves mind. If mind is not an energy-system how will the running-down of the universe of energy affect it? Can it go unscathed? Always so far as we know the finite mind is attached somehow to a running energy-system. When that energy-system ceases to run what of the mind which runs with it? Will the universe which elaborated and is elaborating the finite mind then let it perish?

Our immediate theme was the meaning of the roof-brain for the motor act. We accepted the roof-brain as par excellence that organ where motor act and finite mind get into touch with one another. We felt we had to look upon their contact as a 'contact utile'. The 'how' of it, perennial crux, we left. Over a range of animal life, including all so-called 'higher', motor behaviour in the individual has two components. One component is reflex, which as the originally predominant one we thought of as basal. The other is a superstructure and is not reflex. It is this latter which in the higher animals is supplied by the roof-brain, and is so whether the motor behaviour be instinctive or rational. It became more prominent as man was approached and most prominent in man himself. The spinal reflex in man is never capable of a motor act 'of external relation' with the finesse and precision of the normal act. The roof-brain component increases the finesse, skill, adaptability and specificity of the motor act. Deprived of it the motor act, reduced to the reflex foundation, was found in the highest animal form, and most of all in man, to be imprecise, inconsequent and without 'skill'. In lower animals however the reflex foundation of the motor act was in itself more capable and complete than in the higher. The reflex had normally a larger share in the behaviour. The motor act in that case suffers less on withdrawal of the higher, the non-reflex, component. Even as between dog and man the dog after exclusion of the roof-brain can stand and walk and run competently and direct itself visually. But in man not so. In the dog after exclusion of the roof-brain the motor act can however no longer be adapted to a special purpose or given skill by training. We agreed that reflex action by definition has its initiation from outside the nervous system. The component due to the roof-brain is not of reflex nature. It is intrinsic not extrinsic in origin. Not that the roof-brain is excluded from all reflex action or its reactions from participation in reflex action. In the motor-act the non-reflex component gears into the reflex foundation perfectly. The 'long-circuiting' (Fulton) of sensory impulses to levels of higher integration is in itself a sort of reflex 'call' which climbs to the roof-brain there to incite co-operation. But the roof-brain's contribution to the motor act is not itself 'reflex'. Can we describe what it in all its diversity contributes to the act? It fits it to this or that purpose of the moment which passing exigencies of the animal's situation of the moment would seem to call for. The dog not only walks but it walks to greet its master. In a word the component from the roof-brain alters the character of the motor act from one of generality of purpose to one of narrowed and specific purpose fitting a specific occasion. The change is just as if the motor act had suddenly become correlated with the finite mind of the moment. It is just as if the body and its finite mind had become one!



VIII

THE ORGAN OF LIAISON

Mind knows the world and operates on the world by means of its body. It is hard to escape the conclusion that bodies existed before minds and minds only exist because there are bodies fit for them.

A. D. RITCHIE, *The Natural History of Mind.*

Science has put the old teleology to death. Its disembodied spirit, freed from vitalism and all material ties, immortal, alone lives on, and from such a ghost science has nothing to fear.

LAWRENCE HENDERSON, *The Fitness of the Environment.*

VIII

COULD we look altogether naively at the question of a seat of the mind within the body we might suppose the mind diffused, not confined to any one part. An individual, one's dog, one's self, is a mass of microscopic lives, each one self-centred. It might then perhaps be that our mind, at least so far as sentience, would extend through all our parts. That is not found to be so.

The fact is that the mind—the finite mind of the individual—as to 'place' is related with one only of the systems in the body. That system itself is the opposite of diffused. There are indeed what are called, and justifiably, diffuse nervous systems. They too are built of cells, unpolarized nerve-cells, called 'protoneurones' (Parker). They are however the very simplest of nervous systems, nor have they correlated with them any plainly demonstrable or recognizable mind. The nervous system, though mind ultimately is correlated with it, shows no such correlation primarily. The correlation accrues only when the system is become more complex. A feature which accompanies its becoming complex, is that, polar opposite to diffuseness, it gathers into 'clumps', it segregates into limited masses. That is because its cell-units have to interact and they interact by contact. Hence they clump into definite masses, called ganglia, spinal cord and brain. They have to interact because they have to modify their own and each other's behaviour by interaction. The behaviour of the complex animal, such as the cephalopod, the insect and the vertebrate is largely an expression of this interaction in the clumped masses of the nervous system. The largest of these masses is the brain. It is with that, and not diffused through the body, that recognizable mind correlates. Much as one special organ, the heart, maintains the flow of nutriment throughout the body; so one organ, the brain, is provider of mind for the whole individual. If we smile at so bald a statement we must yet agree that it states the practical situation with which the physician and the surgeon deal.

It shows us too the body in the grip of integration. Much of the body has no demonstrable mind. Of the rest most has mind only lent it, in the form of sensation by proxy. Such of it merely communicates with a certain restricted piece of the body, a particular part of a single organ, and there, so much of the body as feels, has its sensation done for it. There too the body's thinking seems to be done for it, namely, in the brain.

Of man we know even more confidently than of any other concrete life that his mind is correlated with his brain. But let us avoid the sophistication that for the mind to be in the brain is any self-evident proposition. "Many men", wrote Kant, "fancy they feel their thought in their head, but that is a mistake. No experience tells me that I am shut up in some place in my brain." We owe I suppose to medicine in the main the knowledge of where in the body the 'seat of the mind', as it is termed, is. But so far from its being a self-evident fact, one of the greatest of biologists, Aristotle, did not subscribe to it although it was accepted by physicians in his time.

The art of medicine has long stressed the importance of what it calls 'localization'. By that term is meant knowledge of the place or seat within the body of a normal 'function' or of a diseased. Under the Galenical view the source of health and sickness lay in the humours, in the four cardinal humours. Since these extended practically throughout the body 'localization' was at a discount. It was among the merits of Jean Fernel, our sixteenth-century physician, to stress the importance of ascertaining the 'where' of a malady. The lead he gave in localization was due to his conviction that the organs themselves, the 'solid' organs as he called them in contrast to the humours, rather than the fluid humours were seats of function and of misfunction.

The study of the nervous system and the brain entered toward the end of last century on an intensive period of 'localizing'. This was owing mainly to the introduction by David Ferrier, the physician, of the use of induction currents for electrical excitation of the brain. The brain excited at certain points evokes motor acts, or bits of motor acts, e.g. of a limb, of one side of the face, etc. The phrase went that at this part or that part of the brain this or that movement of the arm, or of the face, was 'represented'. It might perhaps have been expected that these movements of the body so easily provoked by the application of electricity to this or that point of the roof of the brain, would be just the stereotyped 'reflex' movements which can be excited, e.g. from the skin and spinal cord. Instances of such reflexes are, for example in cat and dog, the rhythmic scratching with the hind-foot which grooms the hairy coat, or the twitch of the ear when irritated as by a fly, or the shaking of water from the wetted coat, or standing or walking. But no. These movements are not evoked by stimulation of the roof-brain. They are reflex, but not, it would seem, 'represented' in the cortex. Movements elicitable by electricity from the cortex are the turning of the gaze sidewise, climbing and grasping movements in the monkey. These movements carry a different range of meaning from that of the spinal reflexes. They seem rather fragments of motor behaviour which, if we could elicit the whole train, would bear the character of what we called the fringe of a composite act whose focal part occupies the attention for the time being of the 'doing' mind. But it cannot be said that anything closely resembling the performance of a deliberate act, such as one of those which in sequence occupy our attention and make up what counts as our 'doing' for the waking day, has ever been evoked by electricity or any other artificial means from any part of the brain. Thus, no 'word' or even an exclamation or a laugh or groan has ever been elicited, although 'centres representing' speech have been, on other grounds, identified in the roof-brain. Further, it has been found that the several senses, sight, hearing, smell, are 'localized' in certain areas of the brain. This was called sensory localization. Again it was found that the start of an epileptic seizure, some movement or some sensation which ushers in the attack, is indicative, according to its movement or sensation, of that place in the brain which is responsible for the attack. It was all of much importance for medicine.

The 'localization' of mind is however the great 'localization'. That it was not self-evident we have seen. How came it that Aristotle, the 'father of psychology', missed the localization of the mind in the brain? A number of observed facts may have puzzled him. The insensitivity of the exposed brain to handling and wounding; the lack in his time of distinction by dissection between nerves and blood-vessels; again to him, as to Hippocrates, the brain seemed bloodless and he had noted that sentient parts are always fed with blood and that loss of blood brings loss of consciousness. Then, while among his contemporaries there were some who had seen as much of the anatomy of man as he, few or none of them knew with the breadth that he did the structure of other creatures, 'lower' creatures as we say. Of invertebrates some appeared to have no brain; but since these he judged none the less to have sentience, he inferred sentience could not accrue from the brain. He 'localized' mind in the heart. The action of the heart notoriously is disturbed during emotion. Aristotle opined of the brain that it was concerned with that one of the four cardinal qualities, 'cold', which was the specific contrary of the cardinal 'heat' of which the heart was the focus and source. The brain was therefore in his view connected with the organ of mind, namely, the heart, and served the mind although it was not the seat of the mind.

Despite this it was Aristotle by his description of mind, who made to that theme perhaps the greatest contribution not only of antiquity but for our own era so far on as the Renaissance. His faulty 'localization' was soon corrected, and his description of the biological make-up of the mind was taken over and became the paradigm for centuries. His conception of a 'common sensorium', given in the *De Anima*, was fundamental and fertile during more than eighteen centuries. It still survives in a number of current phrases; thus perhaps the phrase 'common sense', as so to say, 'everyday' mind. What is strange, and seems significant, is that his attribution of the mind to an organ so different from that which was the right one occasioned little let or hindrance to his account of the mind as such. An impression left by the *De Anima* is Aristotle's complete assurance that the body and its thinking are just one existence. If his reader interpret that as a materialist view then there is little in the *De Anima* to contradict him. If his reader infer that the description assumes that matter is working itself with mind as its outcome, it seems to me that there is little in the description to forbid that inference. On the other hand materialism as a question seems for all explicit reference to it wholly left aside. But the 'oneness' of the living body and its mind together seems to underlie the whole description as a datum for it all. In terms of today it seems to envisage the problem of integration as dealing with a body and mind whose solidarity is inseparably one. Beside it the disquisition of Fernel holding them apart seems a flight into cloud-cuckoo-town.

It might have been expected that Aristotle's attaching mind to what has proved to be a muscular pump instead of to its proper organ would have ruined his description of mental structure and ways. That it does not notably do so is a gloss on macro-anatomy as any clue to mind. A like reflection arises when we read another original authority on mind, one recently taken from us. It is far from Aristotle to Freud. They are poles asunder. Yet the work of the two has resemblance in one respect. With both of them their study of the mind is wholly detached from anatomical features of the brain. Even as a background to the metaphors and parables, and classical myths, by means of which psycho-analysis proceeds to tell its story, the anatomy of the brain has no more part there than in the narration of, say, Bunyan's *Pilgrim's Progress*. Widely different from the symbolism and semi-drama of psycho-analytic writing, the compact descriptions of the *De Anima* are yet similarly remote from reference to gross anatomy; to minute anatomy they had of course no access. Neither with Aristotle nor Freud does their aloofness from all anatomy of the brain hinder their study of mind from being a great advance in the subject.

Between the study of the mind and that of the brain the gap is wider than between the studies of activity and of visible structure in most organs. Description of the action of a muscle could not dispense with reference to the muscle's visible structure. Reference to the brain at present affords little help to the study of the mind. Ignorance of the 'how' of the tie between the brain and the mind there makes itself felt. That is no fault of those who study the mind or of those who study the brain. It constitutes a disability common to both of them. A liaison between them is what each has been asking for. That there is a liaison neither of them doubts. The 'how' of it we must think remains for science as for philosophy a riddle pressing to be read.* As things stand we cannot be sure that some of the

* Cf. Viscount Samuel, *Nature*, Feb. 1939; C. S. Myers, *Realm of Mind*, p. 112; W. MacDougall, *Outline of Psychol.* (at end).

very terms of approach to mental health and unhealth are not still on a plane with the 'humours' of mediaeval medicine.*

Medicine, with its use for 'localization', has always pressed examination of the 'whereness' of the individual mind in the individual body. This was a feature of the materialism so often charged to physicians. Galen with his didactic power bore witness almost stridently to the localization of the mind in the brain. Aristotle in discounting it had had reasons; he was however wrong. Galen's correction was but a return, with more detailed knowledge, to pre-Aristotelian and to post-Aristotelian teaching. The sacred disease epilepsy, which affected the mind, the Hippocratic writings had allotted to the brain.

There is in Fernel no sign of any desire to bring mind and body together to a unity. Inasmuch as combination of Aristotle's 'form' with the bulked material of the body produces the living harmony it, for the time being, does, Fernel is content with that, and is hardly curious about it further. But he has found himself faced with a 'principle' which works the body and is its 'life' and, over against that, a something in the body, 'intellect' he calls it, which is even more alien from the corporeal. He must bring these two together or the soul will not be one. Aristotle of course was not thus troubled. Tracing all phenomena of the body ultimately to its nourishing itself he described among the phenomena 'mind', and he did not seek to disconnect this latter from the body. His position, in so far, seems not greatly unlike that of Spinoza, except in being more detached from religion.

Fernel on the other hand was much concerned to demonstrate that man the individual has one single soul, the simple singleness of which guarantees it from dissolution. His necessity in this matter inspires his account of the processes going on in the mind and brain. The brain, he is clear, is the place of mind, and he says† of it that shock or compression produces unconsciousness and injuries of it destroy memory and induce madness and delirium. Further, in the Dialogue,‡ he makes Brutus, representing common knowledge, remark on hurt to the brain causing hurt to intelligence.

* Rockefeller Foundation, *Tasks Ahead of Medicine, A Review for 1938*, by Raymond B. Fosdick, p. 29, New York.

† *Physiol.* v, 14. ‡ *Dialog.* II, 4.

The brain for Fernel is in animals the seat of the 'sentient soul', which we may construe as meaning for him 'brute mind'. In man the brain contains as well as a human counterpart of the sentient soul, the rational soul, which comprises intellect and reason. The human soul comprises all these and yet remains single, as a * pentagon potentially contains a quadrilateral or a triangle and yet remains a simple figure. Now, intellect and reason are of an essence which does not need matter, and is immortal.†

Fernel speaks ‡ of the brain as 'castle and fortress' of the 'sentient soul', i.e. of brute mind and its analogue in man. It is the 'proper domain' of sensation and perception.

With Fernel the brain is for refining or dematerializing. The refining is carried to a higher pitch in man than in the brute. In man the process begins in that part of the brain which corresponds with the animal part. Therefore in man and animal its earlier steps are comparable. It is then carried to perfection in the specifically human part. This is of course no hint at evolution. It has in mind Aristotle's 'ladder of life'.

Fernel's scheme runs in this manner. The external sense-organs receive images of external objects. These images owing to attractive force in the sensory nerves travel up to the brain, as animal spirits. They are, although 'spirits', still clogged and contaminated with gross matter. § In the brain they reach first the 'common sensorium', and meet the 'internal sense'. Just as the material qualities of external things constitute the object-matter of the external senses, so the above images, arriving at the sensorium commune, are in their turn the object-matter of the 'internal sense'. After the work of comparison and recognition done upon them by the internal sense and such phantasy as the sentient soul has, which goes as far as distinguishing between a fancied object and a real one, || the resultant percepts, more purified from matter than were the images, pass on to the passive intellect of the rational soul. The percepts are the object-matter of the passive intellect which in turn elaborates from them concepts more cleansed from matter still, but yet

* *Physiol.* v, 2; v, 18.
† *Ibid.* v, 11.
‡ *Ibid.* v, 8.
§ *Ibid.* vi, 14.
|| *Ibid.* v, 11.

only limited and particular concepts.* There is passive intellect and intellect as agent. This latter is a builder of concepts, *architectus notionum*.† It takes over as its object-matter the products of passive intellect, puts a number of them together into one, and expands them and refines them further‡ by abstraction, obtaining general concepts, and universal concepts, and such abstract notions as eternity, infinity, and so on. Such concepts are not, or are scarcely, soiled with matter or by the corporeal. Finally, complete spiritual purity, without a taint of corporeal, is attained by the products of reason which last ultimately arrives at moral judgments§ as to right and wrong.

The argument comes to this: that within the brain certain agents (spirits) of the 'life-principle' are sublimated step by step so that they merge with man's intellect and reason. 'Life-soul' and 'mind-soul' thus become one soul. Riolan the elder,|| Fernel's commentator of the sixteenth century, was, however, not convinced by his author's argument on this point.

Galen, studying the brain in apes and man, was greatly struck by the large hollow chambers within it. They come as a surprise on cutting open so solid-looking an organ. They are four, and they intercommunicate. They contain clear watery fluid. The mind was for Galen, as later for Fernel, a something incorporeal. A 'thing' could be incorporeal both for Galen and Fernel and yet be a thing. The actions of life as far as mind pertains to it, operated the body by the spirits of the anima working the nervous system. The chambers of the brain were for Galen the place of generation and of common assembly of the animal spirits of the soul. Thence and thither they went and came to and from all parts along the nerves. The chambers were therefore the central seat of the operations of the mind and of its spirits. The clear fluid there was their vehicle.

That there should be these large fluid-filled chambers inside the solid-looking human brain is calculated to strike an observer as remarkable. Galen was not a comparative anatomist as was Aristotle. They are disclosed only on laying the brain deeply open. Galen interpreted them to be of key-importance for the

* *Physiol.* vi, 14, at opening. † *Ibid.* vi, 14.
‡ *Ibid.* v, 11. § *Ibid.* v, 19.
|| *De immortal. anim. disputatio*, p. 74. Paris, 1598.

working of the mind. Judging the brain and nerves to be tenanted by subtle and ultra-tenuous spirits, he seems to have said to himself, seeing these chambers, "This is their reservoir." The chambers of the brain have in fact a wholly different significance. The brain as traced back to its beginning, both in the individual and in our animal stock, is a tube. The chambers found later in it are dilated pieces of the tube. The chambers have no nervous significance, except perhaps as increasing the surface of the brain.

There was too a further circumstance which misled Galen and his followers as to the chambers, a circumstance which lent colour to their supposition that the spirits of the anima lived in the chambers. The spirits were a 'cause' of bodily movement and the brain moved. The movement of the heart, familiar to all, was believed due to the rhythmic outburst within it of a lower grade of life-giving spirits, the vital spirits. Thus was viewed what we know now as the heart-beat. The brain's rhythmic movement was taken to be similar. Galen must have watched it not rarely. He writes that war and the gladiatorial games were the greatest school of surgery. The rhythmic motion of the brain may be seen in wounds which open the skull. It is evident also as a rising and falling of the scalp in a young child before growth has closed rigidly the bony vault of the skull.

It is not in fact a movement caused by an act of the brain itself. Its rhythm is that of the breathing of the chest. The chest-movement influences the amount of blood-flow through the brain. Each taking of breath lessens somewhat there the quantity of blood and the brain shrinks in size a little. With expiration the brain slightly refills and re-expands. The brain-movement is thus purely passive. To Galen it betokened rhythmic movement of the spirits of the soul in the chambers of the brain.

Galen's eminence and the subsequent conspiracy of the ages to maintain and exalt it, carried this teaching not only unchallenged but hardened into dogma century after century, down to and beyond Descartes and Harvey. For Descartes however the spirits of the anima were definitely not incorporeal —they were a kind of 'flame',* travelling with incredible

* *Traité des Passions*, iii, 20.

velocity. Harvey was uncommittal and objective. His observations had engaged him for 16 years, but he said in all that time he had met no evidence of the spirits. The negation fell with the force of a positive blow.

Then, in the later seventeenth century, Thomas Willis of Oxford practically refounded the anatomy and physiology of the brain and nerves. Willis went to Nature herself. He was helped by his famous pupil, Robert Lower, the deviser and doer of the first transfusion of the blood. The great 'Instauratio' had begun. The Royal Society was in being. Willis combined medical experience with first-hand anatomical knowledge. He collated bedside observation with anatomical fact. He, as had Fernel a century before him, shifted the seat of the anima from the chambers of the brain to the actual substance of the brain itself. For him, the crust of the brain, grey in contrast to the underlying white matter, was the great seat of the animal spirits. The large masses of grey matter bedded in the brain were, in like manner though to subsidiary extent, seats of these spirits of the soul. From the crust of the brain downward the masses of grey matter were threaded together by white matter. Willis's insight perceived that the white matter was fibrous much as nerve-trunks are fibrous. Willis put the brain and nervous system on their modern footing, so far as that could be then done.

By this time, too, the spirits of the life-soul were tending, literally, to 'materialize'. Only a century before they, in the microcosm of the body, had been the counterpart of the celestial ether in the macrocosm, the universe. Willis, looking at facts for himself, had been struck by the greater richness of blood supply to the grey nervous matter than to the white. He argued from it that the place of generation of the spirits was the grey matter, and that the white matter formed merely their paths of travel. He held that there was a long causeway from the grey crust of the brain down to all the nerves of the body, and that the grey matter scattered along that route provided further generating stations threaded along the pathway of conduction. These points proved to be well taken.

So too was his teaching that such stations, and even the grey cortex itself, were seats of what he called 'reflex action'. As to the 'localization of mind', his view was that the higher up toward and into the grey crust of the brain a reflex action occurred the more did conscious mind attach to it. Willis illustrates, we may think, how far careful bedside observation of disease combined with good anatomical knowledge, but without microscope or any true chemistry, could carry in this field. It was Willis who said of hysteria, thought then, as its name implies, to be a uterine affection, "it is not; it is an affection of the brain."

The views thus opened up might have been followed by a clear run of progress. That did not in fact happen. Anatomy, analysing life in space, accustomed itself to think of time as frozen. Vieussens of Montpellier modified Willis's interpretations and taught that the white fibrous core of the brain, and not its grey crust, was the great reservoir of the spirits. This fibrous 'centrum ovale', as it was called, then became the 'seat of the soul'.

The spirits of the anima continued to become less and less ethereal. Malpighi, the microscopist, bringing his lenses to bear, declared the animal spirits to be a juice. He could see this juice ooze from severed nerve-fibres. This view he developed further. The tubes of the nerve-fibres contained a subtle juice, separated from the blood in the grey crust of the brain by glands there. Any pressure applied to an organ of sense was at once transmitted along the nerve-tube's juice to the brain. Even the corpuscles of light striking the eye started a pressure in the eye-nerve which was transmitted to the brain. The pressure carried thither was thence directed to the motor nerves. These views went abroad as portents that the long reign of the immaterial spirits of Galen, some say derivable from Plato, was nearing its close. Their next transformation was to be the eighteenth-century *vis nervosa*, a species of the genus 'vital force'.

A strange episode chequered the even course of their road to dissolution. A reaction of itself little worth entering into save for an interesting comment which it evoked. The time was the very end of the eighteenth century. Galvani, chastened by Volta's criticism, was actually ushering in the modern reading of the animal spirits, when at Königsberg a laborious anatomist, Sömmerring, had an idea. He had published many drawings of the gross anatomy of the brain. He had acquired merit by renumbering yet once more though incorrectly the cranial nerves. Then, at climax of his maturity, he reported the ultimate finding of his toil, to the effect that the soul resides in the water of the brain. He said also, that although he had read widely, he had not met that idea elsewhere! To crown his discovery he dedicated this final work to his fellow-townsman, Immanuel Kant, philosopher.

There were no doubt those who smiled. Kant faced the situation with stoic courtesy. He acknowledged the compliment. He met the request for his opinion by a lengthy letter, addressed to the author. He wrote, "We are told now by this discovery that the common sensorium is neither more nor less than the water in the chambers of the brain. There it isolates the nerves whose ends pass thither so that the sensations are not confused. It is at the same time a medium of communication between them."

"A difficulty", he goes on, "is that water is not organized. Without organization no matter can be thought of as providing an organ for the soul. However, if we turn from the mechanical uniformity of water to its chemical composition there is more scope. Water has now been split by pneumatic experiments into two gases [Cavendish, 1781]. Each of these gases besides its own basis has caloric. This latter may be decomposable into light and other material like light, which again is decomposable into colours", and so on. "A drop of water, a grain of sand, or things even more simple still, are inexhaustible in the diversity of their least parts, even to an understanding so limited as man's." Plants extract from water a vast quantity of matters. Who knows what the nerves might find to their hand in the water of the brain? "Suppose the nerves in their several kinds can decompose the water in the brain, its elements may give rise to different sensations. The excitation over, the elements might then reunite. Thus, what this book claims might come to pass."

But the seat of the soul? No. "One cannot assign a relation in space to what is determinable only in time. Many fancy they feel their thought in their head, but that is a mistake. The mistake is to infer that the cause of sensation is there where it is experienced. They attribute thought to traces in the brain left by impressions of sense. These supposititious traces carry no inference as to the seat of the soul. It is just material acting as at the common sensorium, as at an antechamber of the mind. Water within the chambers of the brain might truly be a common sensorium. But seat of the soul? No. That leads to $\sqrt{-2}$, an impossible quantity." *

So after more than twenty centuries of human enquiry, from Hippocrates to Kant, we see the mind on the one hand given as its seat, the water in the brain by an investigator for whom such questions had been his life-study, and on the other hand denied any restricted bodily seat whatsoever by a philosopher perhaps the foremost of his time. After twenty centuries the relation of the mind to the body had not been resolved. But the plain man in the street had come to his pragmatic conclusion.

As for Galen's spirits of the anima, for Fernel, as workings of the anima, they belonged at once both to soul and to body. They were the mind and also what it bodily did. Descartes had brought them down to earth. For him although very subtle they were material, akin to flame. Their death-knell rang when Lucia Galvani told her husband Luigi that the frogs' legs prepared for the meal seemed alive on the copper-wire. Slowly and surely the ensuing century's analysis resolved this aspect of the spirits of the anima into transient electrical potentials travelling the fibres of the nervous system. They were no longer 'spirit', but were become a physical event describable under energy.

Their innings had been long. It had lasted from Galen to Galvani. They had dominated medicine and biology through Alexandrian, Christian, Arabian and Jewish learning. Theirs had been a privileged position. The universe, the macrocosm, had its messengers, its 'angels', between the corporeal and the occult. So the microcosm, man, had similar messengers and these were they. They were analogous to the astrologers' 'astral fluid'. The more mysterious they were, the more votaries they had. In his sixteenth century, Fernel could write of them that they are therefore an etherial substance, tie between the vital heat and the faculties (of the soul), the prime instrument of all function. † They had seen much betide. They had seen the Empire become Christian. They had seen the Empire 'fall'. They had seen Christendom reconquer its conquerors; in all

* *Sammtl. Werke*, x, 112 (Hartenstein, 1839).

† *Physiol.* iv, 2, 81.

those phases they had endured as an abiding belief. They had seen the Mediterranean become, for a time, an Arabian lake, and along with Islam's domination, theirs had spread. They had seen kingdoms shape and nationhood arise, and their place had remained theirs in both. Vernacular tongues had replaced the classical even in Church and Medicine, and they had entered into them. They had been at the law-giving of Justinian and had outlived its decrees. When the known world expanded almost yearly they had expanded with it. They had in the scholastic age been a means of magic, of the basilisk's fascination and of the 'evil eye'.* Scholasticism passed but they kept unchanged. They had outstayed wars and pestilence, political convulsion and religious schism. Then, late in the seventeenth and in the eighteenth and nineteenth centuries, their own dissolution had set in. It dated from Nature's coming under enquiry in a new way. It was neither political tyranny nor revolutionary violence which killed them. They expired quietly under the increasing pressure of an effort not consciously directed against themselves, but merely intent on first-hand enquiry into Nature with each step assured by observational experiment. A special menace for Galen's spirits lay in the gradual reshaping which the concept of matter underwent.

Matter was recognized as behaving in certain ways which could be used as touchstone for it. The 'spirits of the anima' would have either to lie within matter or outside it according to their behaviour under these tests. They could no longer have it both ways. In result they suffered a two-fold mode of disappearance according to which of two executioners presided. In the refrain of the old comedy, they "could be two ways killed; or like the bottle broken or like the wine be spilled".

They had vaguely spread themselves into two categories. Ejected from both there remained of them no trace. What of immaterial they had claimed, mind took over. What of material they had stood for, became transient self-mending electrical leaks travelling along nerve-fibres. Science can never be poorer from advance in knowledge, but Fernel, were he with us, might remark,

* Nicolas Oresme (Bishop of Lisieux), *De fascinatione* (1370). Cf. Thorndike, iii, 436.

"the spirits had been at least a 'scientific' liaison between mind and body, and now there is no scientific liaison between them".

Not that the electrical leaks stepped into the material shoes vacated by the spirits quite at once. There was some hesitation as to what should follow. A convenient temporary stop-gap was one of a family named 'forces', which are 'causes' which compel matter to perform certain acts, for instance to fall, or to levitate. The particular one in question was a 'vital force', a principle said to be peculiar to living things. A special representative of 'vital force' was invoked to operate the nerves, the *vis nervosa* or 'nerve-force'. This served during a period of transition.

But electrical experiment found more to say. Induced electricity proved an ideal excitant for nerve. The idea grew that 'nerve-force' was 'electricity'. Galvani's 'animal electricity' gave an impetus to that idea, and that idea a great uplift to Galvani. The notion was welcome to materialism. Materialism had long asked to possess the soul and Galvani's observations seemed to promise it immediate possession. His experiments claimed to prove electricity demonstrable in living nerve. He made the claim in all good faith, and the public forgot or never heard, that Volta the physicist had soon shown Galvani's inference from his experiments to be mistaken.

Galvani had however a right instinct in pursuing electricity into the body. The signalling which goes on in the nervous system is essentially electrical. Electrical reactions are at the same time so all-pervasive and so readily generated that an experiment intended to test this or that part of the body for their natural presence may by its own procedure generate them and then suppose them inherent in the living tissue, mistaking artefact for natural feature. We do not dip a pen-nib into the ink without generating an electric current. Galvani was at first mistaken in this way. It was only years later and after Volta's criticism and by taking more precautions that he, or rather his nephew, Aldini, finally got the experiment right. The best technique for studying the activity of the brain and nerve is today electrical. A stately University Building, in one of the capitals of Europe, erected as an Institute for physiological research, bears in golden letters the device "Life is electricity".

It dates from the last decade of last century. Time has justified its motto of 50 years ago in so far that physical science tells us now that the structure of matter and the doings of energy can all be considered ultimately electrical. The device has proved to be demonstrably true, if from life we subtract the *mental*, holding in that respect our judgement in suspense. There the device has still to establish its right.

Galen's spirits had worked the mind as well as the body. They had been a compromise, based on a confusion. They had confounded two incommensurable things. They had given divided allegiance and they fell between two thrones.

Their story is part of a more general one. Life, supra-material though it had seemed, as knowledge got nearer to it, had resolved itself into a complex of material factors; all of it, except one factor. There science stopped and stared as at an unexpected residue which remained after its solvents had dissolved the rest. Knowledge looking at its world had painfully and not without some disillusions arrived at two concepts; the one, that of energy, which was adequate to deal with all which was known to knowledge, except mind. But between energy and mind science found no 'how' of give and take. There was co-existence; that was all. To man's understanding the world remained obstinately double. Busy common sense went forward treating the two-fold together as one.

So we are back whence we set out, the localization of the finite mind. To speak of the roof-brain as the 'seat' of the mind, or to call some part of it the 'seat', e.g. of vision, is often held to be open to objection. It is so if it imply that a something which is 'vision', or which is 'consciousness', has, in Fernel's phrase, its habitation in this or that part of the brain, and there remains and, so to say, waits and can be found waiting to do this or that when wanted. What the facts assure us is that without a particular restricted piece of the roof-brain vision is not possible. Neither of course is vision possible when the eye-balls have been lost. But we do not interpret the latter to mean that the eye-ball is the 'seat' of mental seeing. The difference is that the roof-brain is concerned with 'mental seeing', but compasses it no longer when a particular restricted part of itself is destroyed, although destruction equally restricted in the roof-brain elsewhere does not annihilate 'mental seeing'. 'Mental seeing' seems therefore to have space-relation with the roof-brain and mental seeing is as its name implies an operation of the mind.

A characteristic feature of the life of the brain is its diurnal cycle of alternation of action and inaction, the phases known as waking and sleeping. What we understand by 'action' is local partial disintegrations, soon made good by corresponding reintegrations. Repeated sufficiently often these transient disturbances leave a cumulative residual alteration which is 'fatigue'. At the end of the prolonged phase of repetitive 'activity' lasting the waking day, there is need for 'rest', for 'recuperation'. This recuperation is given by sleep. A phase to be thought of less as quietude than restorative activity in what has suffered wear and tear. There is building and maintenance of polarized surfaces. The oxidation processes decline. Many organs besides the brain have cycles of alternating activity and so-called 'rest'. The 'rest' is not inactivity. Thus the digestive glands. The stomach glands at meal-times secrete and between whiles pass through a phase of so-called 'resting-state'. But this latter is not quietude. It is a phase of intense preparation for the next secretory period. The two phases are antithetic even to the extent of the one undoing what the other does, but both of them are activity. Again we hear it said that life-long the heart never rests. It would be as true to say that throughout life it is taking rest. Each interval between its beats is rest. But that 'rest' is not quietude; it is change of activity, rebuilding what 'activity' in the reversed direction had broken down. Nature has never invented a wheel, but had she done so we may think her wheel would periodically reverse.

This phasic alternation of activity and recuperation in the brain divides each of us, life-long, into two alternating individuals, a waking and a sleeping. The alternation in the 24 hours is thought to be 'symptomatic' of our full-sized brain. The infant brain has briefer phases. In the aged again a series of shorter sleeps becomes the rule.

Fernel had his explanation of sleep. The animal spirits, those messengers which travel the nerves, are, although quasi-incorporeal, yet subject to the fact that motion cannot be perpetual. At intervals, therefore, the motion of these spirits lapses exhausted. That exhaustion of the spirits, especially as affecting the great 'internal sense', finds expression as sleep. He is following Aristotle. This account of dreaming sleep takes him further than he goes elsewhere towards a notion of the 'self'. When the 'internal sense' is entirely in abeyance we have dreamless sleep. When one of its faculties, namely that of imagination, is still active, dream results. Then follows the remark that in the normal waking state the imaginative faculty is controlled by memory: the inhibitory control of imagination by memory seems implied, and further the notion of a unified something conscious of that result.

Perhaps a first question about sleep is "how do we keep awake?" There is a word which, like many, sometimes used well, has sometimes been used perplexingly. In Greek medicine the healthy tautness which our muscles, even when not engaged in executing a movement, still keep, was likened by the Greeks to the tension of a tuned string, and spoken of as τόνος. Applied to muscle (ὁ τῶν μυῶν τόνος) the term had in mind the mild grade of steady action of our muscles when for instance they simply maintain a posture. For instance in maintaining the straightened hip and knee while we stand. Later in the seventeenth century, much confusion overwhelmed the term. Warped from its clear Greek meaning it came to stand for a mysterious vital principle speculatively supposed (Stahl) immanent in every living part. When with further knowledge this attribution was dropped the term still clung to muscular or nervous actions which endure for long periods at a time. The little iris muscle which surrounds the pupil of the eye keeps up hour after hour a certain constriction moderating the entrant light. This contraction is called 'tonic'. The nerve-centres governing the muscles which keep us erect preserve a steady moderate action, again called tonic action. They, as it is expressed, 'exhibit tonus'. The tonus has among its effects this, that change to fresh or further action is more ready and the more prompt. There is no waste of time taking up slack. The nerve and muscle are like a tuned string always ready to be played on. The nerve-centre is alert for its next order. The state of action is mild, and relatively untiring. A slow rhythmic nervous discharge of some ten impulses a second maintains it. It does incur in the long run some cumulative fatigue. It meets admirably the desiderata for our motor acts. If the next thing needed of a limb is to take a step, some muscles will have at once to act more, others to act less. The change is effected smoothly by merely increasing the rate of firing of the tonic nerve-units and bringing more units into the firing-line. The slow-firing tonus becomes collectively a quicker and heavier fusillade. A photograph of the activity shows simply a quicker-running and more overlapping series of electric waves. With such increase in one nerve-centre runs decrease in another. Moderate action already in process provides the favourable basis. In a muscle slack and out of action further moderation of action is precluded; grading in that direction there is none.

In a nerve-centre tonus carries with it, besides its overt discharge, a fringe of subliminal preparation which is favourable for ensuing change whether of increment or decrement. More than that, the subattentive or subconscious fringe of mind which takes such a share in the management of our motor acts is not 'aware', even subattentively or subconsciously, of a muscle which has in it no action at all. Of a muscle in tonus it is 'aware', it is kept 'aware' by the 'tonus' acting on its muscle as a sense-organ. It is 'aware' much as an angler by the 'feel' of his line is kept aware, ready to 'strike' should anything meddle with the bait. This submental 'vigilance' is in effect a state of nerve-centre ready for immediate response to anything fresh. Such the meaning and value which the so-called *tonus* of our muscles carries.

We spoke earlier of the 'knee-jerk'. The knee-jerk is a touchstone for tonus. It illustrates tonus as a state of vigilance. When its muscle is toneless even a heavy tap will hardly provoke the jerk. When tonus is good a tiny tap not stretching the muscle by 1/1000th of an inch evokes a brisk jerk and within 1/100th sec. The muscle and its nerve-centre are awake and vigilant.

A few years ago it was found that electrodes placed on the surface of the head can detect rhythmic electrical waves in the brain; much as electrodes to the chest detect the electrical wave of the heart. The brain-waves are oscillations of potential recurring about ten times a second. They are most pronounced at the back of the head; there, as has long been known, the brain is richly connected with the eye. The rhythm of the waves is most distinct when the eyes are shut. To open the eyes is immediately to disturb the rhythm. There is then an outburst of quicker and more irregular electrical firing. Adrian and Matthews trace this alteration to the circumstance that the brain-cells become unequally excited and so fall out of time with each other. It reminds us of the nervous tonus of a muscle and its heightened discharge when called into fuller activity. The tonus of brain and of muscle are both of them cases of vigilance.

This vigilance of the roof-brain is suspended in sleep. The rhythmic volleying slackens. In deep sleep it may drop to barely three a second (Gerard) or may cease altogether. In such sleep "a stimulus which does not arouse the sleeper may evoke a few waves or a brief outburst at ten per second" (Adrian). In light sleep short groups of waves occur at times, and anything tending to waken the sleeper may start a series of them. If he wake, the electric waves (with eyes closed) regain their normal size and regularity. And if he then 'look at' anything, even in thought and without opening his eyes (Adrian and Matthews), the full tumult of complex waves sets in at once. Observations have been made under drugs which induce sleep. The noise of a rattle will then excite in the hearing part of the roof-brain a transient train of electric waves (Bremer). But the brain soon relapses into repose. Activity of the brain demands oxidation of sugar (glucose). Narcotic drugs are found to interfere with this oxidation; the greater the narcotic power, the greater the interference with the oxidation. There comes a stage in narcosis when the electrical waves subside and altogether cease. This desistance of 'action' is profound slumber. With waking the electrical waves return. Like the vigilance of tonic muscles, this background activity of the roof-brain, which persists in our waking state and even in light sleep, can be regarded as a 'tonus' of the roof-brain (Bremer). Deep sleep is a lapse in that tonus; narcotic drugs can annul it absolutely.

Is the tonus, this electrical throbbing of the roof-brain, due to automatic action of the roof-brain itself? The heart's beat is self-fired. There are certain parts of the brain that are in rhythmic action all life through. Like the heart they generate action within themselves in absence of influence from without. 'Autochthonous' perhaps better describes it than 'automatic'. The 'respiratory centre' which operates the rhythmic ventilation of the chest exemplifies it. On the other hand, those tonic centres which operate the 'postural vigilance' of our limbs, and served us as prototype of the tonus or vigilance of the brain, are not automatic. They are driven by a stream of nervous influence, partly from sense-organs driven in their turn by the tension of the tonic muscles themselves, partly by the geotropic organs of the head. With which of these two types of tonus and 'vigilance', the autochthonous or the reflex, must we class the tonus of the roof-brain and its concomitant, brain vigilance, the basis of the waking state?

Climbing to reach the vast nerve-cell jungle of the roof-brain are multitudes of paths from the scattered organs of practically each and all of the modalities of sense. Minute anatomy has long shown this. Upon the great nervous complex of the roof-brain play eye and ear, and skin organs, and have there their special fields. Physiology has recently detected (Bard)* that even a fleeting touch say on the foot, is followed a moment later by electrical disturbance, fleeting also, at a definite spot of the surface of the roof-brain. The position of the brain-spot varies within limits with the place of the touch on the foot. There is, so to say, a map of our tactile skin spread out on a field of the surface of our brain. This tactile area is separate both from the auditory and the visual. Each has its proper area. A narcotic drug suppresses all these responses of the brain. The brain as sentinel is then drowsed. But during normal waking the roof-brain would seem to be unremittingly stirred by impulses from the various organs of sense. The waking roof-brain is found never free from electric action. The wonder is that it ever knows anything like a 'steady state'. Yet, to judge from our mind, it does reach an approximately steady state. A steady background over which our conscious attention shifts, fixing on this or that, to stress it, and even to assess it, in this respect or that, against that background which it conceives as steady. The 'I', the attentive 'self', is wont to take for granted that its own

* Philip Bard, Harvey Lect., *Bull. New York Acad. Med.* xiv, 585.

background from occasion to occasion has remained a standard one.

We were asking whether the tonus of the roof-brain is autochthonous or reflex. That is, whether the roof-brain keeps itself awake or is kept awake by the senses and their annexes. There are instances known to the physician where disease closes almost all the main channels of sense. It has been noticed that then sleep can be induced at any moment by shutting off some main remaining channel. Thus, to close the remaining eye will bring on sleep at once. Laboratory experiment here brings a decisive word. It can at a stroke shut off the stream of impulses reaching the roof-brain from the sense-organs. When that is done sleep follows forthwith (Bremer).* If a channel of sense be left still available, for instance one ear, then through that channel the sleep can be broken. But following that interruption sleep at once returns. It would seem that the tonus of the roof-brain depends for its upkeep on the influences reaching it from channels of sense. They cumulatively and additively play upon us throughout the waking day.

This analogy between the roof-brain tonus and the postural tonus of the muscles is noteworthy. In both the mechanism seems 'reflex'. The drive of the tonic vigilance of the muscle-centres is mainly from muscular and geotropic organs and is subconscious. With the tonic vigilance of the roof-brain the drive is mainly from organs of sense in the fuller meaning of the word, from eye and ear and skin. It belongs to consciousness as well as to the unconscious. This in so far harmonizes well with the Aristotelian "omnia a sensorio" (Bremer). Sir Henry Head, in his studies of cerebral function, identified a fundamental factor in mental activity as what he termed 'vigilance'. His conception and the term he chose for it convey much of what seems the mental counterpart to the tonus of the roof-brain and its underlying adjunct, called anatomically the thalamus.

But in the physiological mechanism of waking and sleeping there is yet another element. Anatomically the roof-brain spreads like a vaulting over the so-called stem of the brain which supports it like a column. Buried in this stem where the shaft

* *C.R. Soc. Biologie*, cxxvii, 355; and *Boll. Soc. Ital. Biol. Speriment.* xiii, 271–90.

is still slender there is a place which, when excited by the electrical current, immediately induces sleep. "The cat purrs, looks round for a corner, settles down there, closes its eyes and sleeps." We do not know how this sleep-compelling centre below the roof-brain brings its effect about. Not far above it the nerve-paths climbing to the roof-brain from the various sense-organs enter 'relays' on their way thither. A relay in a nerve-path gives opportunity for a side-influence to facilitate or impede the travel through the path. One suggestion is that the sleep-compelling centre induces sleep by blocking at this relay the stream of sensory impulses which, as we saw reason to think, keeps the roof-brain tonic, that is, awake. Now the roof-brain itself sends paths down to this organ of relay (the thalamus) as well as receives paths from it. A dilemma for the physiologist in deciphering the meaning of a nerve-path leading from one nerve-centre to another is that an anatomical nerve-path may mediate either of two antagonist effects, increase of action, or decrease of action. It may mediate either or both. Only direct observation can decide this dilemma for any particular conducting nerve-path.

One thing clear is that when we drop asleep co-operation obtains between a decline of tonus in the roof-brain and a definitive intervention on the part of the underlying sleep-compelling centre. This latter consummates the tendency of the former by a hypnotic act. The roof-brain, by paths of its own which it sends down to the relay-organ, the thalamus (Earl Walker), may be acting to keep those relays open and so feed itself with sensory influences to keep itself awake. And it may be at those very relays that the sleep-compelling centre acts by blocking the sensory influences which keep up the waking state. When at the end of a long day the nerve-cells of the roof-brain grow fatigued and blunted to the sensory stream playing on them, the roof-brain's tonic vigilance begins to give way. It can still be whipped up by a busy incoming of messages from a sense or from elsewhere. But there is increasing tendency for the tonus to abate, the awakeness to be less intense and less alert. Then it would seem the sleep-compelling centre intervenes with rapid effect. It cuts down further the stream of sense-impulses playing on the tired roof-brain. It relaxes the muscles of the body; it suppresses active movement and even active posture; the eyelids fall; roof-brain activity sinks below waking level. The tired brain drops asleep.

> Turn the key softly in the oilèd wards,
> And seal the hushèd casket of my soul.

It is as though a poet a hundred and twenty years ago had foreknown the mechanism now discovered.

This reaction of falling asleep seems at first sight the pursuance of a vicious circle. Fatigue, tending to incapacitate, releases a mechanism which incapacitates altogether. But as we saw, 'rest' in the physiological sense is not sheer inaction. That further incapacity, sleep, ensures the restoration of the delicate mechanisms whose impending exhaustion induced it. Dr Bremer, a special authority on all this subject, writes, with picturesque power,* "the sleep-compelling centre can be likened to a faithful watchman. From his post in the stem of the brain he perceives the giving way of the waking activity of the roof-brain; wisely then he extinguishes the lights and draws the curtain for the good repose which shall restore his master."

The restoration is mental as well as physical. The tie is close between this mind which is 'awake' so long as the roof-brain is in tonus, and that brain during whose quiescence the mind itself lapses and goes off duty. Not that with cessation of the roof-brain's tonus all activity in it, chemical and physical, ceases. Far from that. What happens is that certain kinds of chemical and physical activity subside, while other kinds go forward. The waking mind is so correlated with the waking roof-brain that, we may say, one phase of the brain's chemistry is associated with 'mind awake', and another phase of its chemistry with mind in abeyance. It would seem the mind has chemical aspects!

Further inference rises. It might have been that dealing with the number of different parts and actions of the body which it does, the roof-brain would be a multiple organ, multiple in its behaviour and in its own intrinsic fields of action. But no; in

* *Boll. Soc. Ital. Biol. Speriment.* xiii, 271–90.

its sleep-reaction it shows itself to be one mechanism. It lapses from the waking state as one. It returns to the waking state as one. So too, in like manner, the conscious mind; it treats sleep as a whole and sleep treats it as a whole. "Sleep and his brother Death", there is the seeming resemblance between them that, to the naive observer, in both cases the 'soul' has flown. Because the tonus of the roof-brain has fallen below a certain level, the soul has flown! Because? Yes, it might seem so.

Knowledge, medical and other, allocates the 'seat' of the mind, as the phrase is, to the brain. That localization has importance for medicine. It may be asked however whether for the scope of what we have before us here, it has importance. It would seem to have importance and in this way.

The two concepts mind and energy, which our experience finds, using the one where the other fails, cover all our experience, are both of course in themselves creations of thought. But what they respectively stand for still remains divided as having nothing in common except time and this curious one and only point of spatial relation, namely 'collocation in the brain'.

Medicine's localization of the mind in the brain is therefore not only in medicine itself the greatest of all the brain-localizations. It is from the more general point of view a lonely datum correlating mind with place. In that respect the evidence it brings is of fundamental interest. It assures us that, as known to us at least, mind is always and without exception individual mind. That is to say, mind in the general and aggregate as known to us is always many contemporary minds. It tells us that the mental as we know it is always in actuality a limited and impermanent individual system.

In many of its bearings the relation between mind and energy seems, although touching life at countless points, too subtly elusive to be captured for examination. In this one instance, however, the elusiveness seems set aside; for the brain and the psyche lie together, so to say, on a knife's edge. Whatever the solution of the problem we can here feel this. That in the energy-pattern which is the brain, two sets of events happen such as, to human knowledge, happen nowhere else the perceptible universe over. In that universe, sampling it, standing where we do on our planet's side, ourselves compact of energy, nowhere does our glimpse detect in all the immensity of energy any relation of energy except to energy save in this one instance, the brain. There energy and mind seem in liaison as to place.

Mind, always, as we know it, finite and individual, is individually insulated and devoid of direct liaison with other minds. These latter too are individual and each one finite and insulated. By means of the brain, liaison as it is between mind and energy, the finite mind obtains indirect liaison with other finite minds around it. Energy is the medium of this the indirect, but sole, liaison between mind and mind. The isolation of finite mind from finite mind is thus overcome, indirectly and by energy. Speech, to instance a detail, illustrates this indirect liaison by means of energy between finite mind and finite mind. I have seen the question asked "why should mind have a body?" The answer may well run, "to mediate between it and other mind". Philosophical speculation might be tempted to suppose the main *raison d'être* for energy in the scheme of things to be this. Energy provided as a medium of communication between finite mind and finite mind. It might be objected that such a view is undiluted 'anthropism'. To that we might reply, anthropism seems the present aim of the planet, though presumably not its enduring aim. Man will, we may think, go; and anthropism cannot be when man is gone.

If we suppose the planet's programme be expression of an aim, then trying to read that programme to learn whither the aim would, surely we do well to draw what inference we can. It may be that the aim toward which what we observe as progress moves includes the human as step to a further stage, of which we may forecast it will be supra-human. If mind, as we experience it and argue it in others, seem to itself that which the programme of the planet has aimed at, and if 'more mind' seem what the planet would and the communication between mind and mind foster more mind, then to hesitate to read this message because it seem 'anthropic' is to be blind to our cause and to that of our planet, of which latter cause, it would seem for the moment, ours is a part.

For energy to be the only means of communication between finite mind and mind seems at least a significant fact in the economy of life. It is a special service rendered to life by energy. It is also yet one instance more of the unity of the complex of which energy and mind seem the two ultimate constituents, for unless mind have working contact—'contact utile'—with energy, how can energy serve it?

IX

BRAIN COLLABORATES WITH PSYCHE

There is however one peculiar inconsistency which we may note as marking this and many other psychological theories. They place the soul in the body and attach it to the body without trying in addition to determine the reason why or the condition of the body under which such attachment is produced. This would seem however to be a real question calling for solution.

ARISTOTLE'S *Psychology*, i, 3, §§ 22–3.
(Wallace's translation, p. 35.)

Further I cannot admit that the connection of soul and body is really either intelligible or explicable.

F. H. BRADLEY, *Appearance and Reality*.

IX

THE body is of cells and like the rest of the body the brain is of cells. Have then the cells of the brain mind and the body's other cells not? Supposing a cell to be sentient, surely we have little chance of knowing whether it be so. A well-versed observer of the one-celled animal world has said that were an amoeba as big as a dog we should all acknowledge its mind. We could then put many more questions to it, but, with all deference, I am not clear that mind would be recognizable in the answers given. Aristotle knew the exposed human brain insentient when touched or manipulated. For him to remark the fact it must have seemed to him noteworthy. Today the surgeon reports that he removes large areas of the cortex of the brain—the cortex is the region where brain and mind meet—from conscious patients without their noticing difference or change. This insentience of the brain may have conduced to Aristotle's view of the heart rather than the brain lodging the mind. But we can understand that the brain in order to feel may have to be approached in a right way. If the brain be mechanism and the mind be related mechanism then it will surely be so. The wireless set answers to turning the switch but not to shaking the box. The connection of the brain with mind seems to rest on the organization of the brain, and that organization is cell-organization. Does knowledge of that organization help us to understand the organization of the mind?

The organization might bring out by additive processes a cell-attribute too slight for detection in the single cell yet obvious when summed. What evidence is there in general of mind attaching to any single cell? This question seems to put itself again. An attempt at answer may at least serve to expose the difficulties. As always an observer's only means of inferring mind, other than his own which he experiences not infers, is behaviour; motricity is the behaviour he can here observe.

Many forms of motile single cells lead their independent lives. Some of them are free single-celled animals. Their motor behaviour can be watched with the microscope. We have already mentioned some of them and their ways. They swim and crawl, they secure food, they conjugate, they multiply. The observer at once says of them "they are alive"; the amoeba, paramaecium, vorticella, and so on. They have specialized parts for movement, hair-like, whip-like, spiral and spring-like, we might call these their motor-organs. Sense-organs, beyond a pigment spot, seem to inspection wanting. Of anything doing duty for nerve there is no trace. But the cell framework, the cyto-skeleton, might serve. There is therefore, for such mind as might be there, no need for our imagination to call halt and say "the apparatus for it is wanting". Doubt or denial will have to rest on other grounds.

Their motor behaviour presents to observation nothing which the pure chemistry and physics of the successive situations circumstancing these lives cannot plausibly account for. The morsel engulfed. The movement toward a sapid particle. The withdrawal after a collision. The preferential seizure of this particle rather than that. The chemistry of the cell reacting chemically to the chemistry of the little field around, that seems the key to it all. It seems as chemical as chemistry in a test tube. There are however observers of skill who after devoting patient study to the motor behaviour of such single-cell lives conclude that, in some cases, there is evidence that the behaviour is modifiable by experience; that this microscopic single-cell life, without sense-organ and without nervous system, can learn.

Two difficulties confront us. There seems no lower limit to mind. The mind which we can infer and, so to say, observe without difficulty and recognize, as we go about dealing with it in our daily intercourse, is that of our human kin. To it our experience of our selves is guide. Our motor behaviour and theirs are interpretable each to each. But security of inference regarding mind fades as traced downwards along the scale of being. At last we descend to a phantom thing the last trace of which who shall discern? Ultimately mind so traced seems to fade to no mind. It becomes so meagre that the problem becomes that of trying to prove a negative. Thus, for instance in the series of organisms of our own stock, is mind recognizable in the cartilaginous fishes? The reply comes, "fish can learn".

That inference perhaps allows them mind. Can we think that that mind is mind near its lower limit? What of a mind which cannot learn, which is perhaps merely a blind urge toward food, or a call toward light, or into shadow? Mind with nothing left but the potential germ of what in evolution's hands has budded into recognizable mind. 'Mind' at the edge of 'no mind'. We suppose a vanishing point. But is there one?

Aristotle noted of life that its lower limit defies demarcation. The living and the non-living, he thought, merge one in the other gradually. To-day the very distinction between them is convention. That deletes 'life' as a scientific category; or, if you will, carries it down to embrace the atom. Either way, the vanishing point of life is lost.

Traced in the other direction, that is upwards, it would seem that, at least as regards cognition, mind as we know it has for this present its acme in the mind of man. Has the evolution of the brain produced mind out of no mind? But we have seen evolution does not create. All it does is, out of something which was, to construct something further. The fundamental is still unchangeably there. Mind we think of as *sui generis*. Admittedly it seems not physical energy. The energy-concept of Science collects all so-called 'forms' of energy into a flock and looks in vain for mind among them. But mind has evolved. What has evolution had to evolve mind from? What has mind evolved from? Has the evolution of the brain compassed the evolution of the mind or how has the evolution of the mind accompanied that of the brain? It is as though the elementary mental had never been wanting; as though evolution in dealing with the brain had taken that elementary mental and developed it until it blossomed into evidence.

Somewhat in that sense 'emergence' is sometimes used for the evolution of mind. The word seems appropriate enough, but its use instead of the word evolution runs the risk of detaching mind from the rest of the evolutionary story. That might tend to obscure the significance of the evolutionary story as a whole.

To our friend Fernel in his sixteenth century the story appeared otherwise. He writes:* "So it is that this part of the soul which is the mind (*mens*) and excels in the dignity of

* *De Nat. Parte Med.* vii, 13.

reason, is, seeing that it is separable from the body, in no way included in the potentiality of matter, from which it can at last go forth after a time. Yet being plunged within and mixed with the body and always having need of its help and its presence, it shall not reason nor understand nor do any other thing without its organ, the body." Two and a half centuries after him Kant touched on this point and to somewhat the same effect, thus:* "Whether after death the mind despite the permanence of its substance can continue to think and to will is not possible to say. In other words, whether it is not or is a spirit (*Geist*), meaning by that a being which without body can be conscious of its own self and of its presentations."

Fernel goes on:† "Created at the beginning by the sovereign Author of all things this part of the soul passes from or comes into the body in a moment. The infant is prepared and formed for it. It is believed that its entry happens in the fourth month, by which time the heart and brain are already there and complete." The recital trips along simple as a fairy tale.

And the same story repeats itself in another setting and again asks for comment from some commentator. The time-relations are, it is true, so changed as to be of a different order; the few months appear as a fore-shortening of some hundred million years. The initial stage of each individual of us, when he or she is a single cell, is its starting point. We have agreed that mind is not recognizable in any single cell we ever meet with. And who shall discover it in the little mulberry-mass which for each of us is our all a little later than the one-cell stage; or even in Fernel's 40-day embryo? Yet who shall deny it in the child which in a few months' time that embryo becomes? Here again mind seems to emerge from no mind. So, conversely, at death it seems to re-emerge into no mind. Energy is indestructible and that it is so Natural Science finds, in so far, demonstrable. But mind seems to come from nothing and to return to nothing. The devolution into nothing seems as difficult to accept as the evolution out of nothing. If the mental were some form of the energy it so adheres to, the story would be no more than one of energy-transformation. But Science fails us if we ask it for a

* *Sammtl. Werke*, VIII, 570, etc. (Hartenstein)

† *De Nat. Parte Med.* VII, 13.

form of energy which is mental. Energy seems in the last resort movement. If the nature of the mental were movement, we would think some form of energy would subsume it.

To return. How does mind come to evince itself by association with the brain? No cells seem more remote than they of the brain from those single-cell individuals we spoke of with their restless and purpose-like ways, observable by the microscope, to which mind is attributed by some who study them. Instead of single-celled freedom the cells of the brain are anchored and characteristically touch together at points. At one time it was thought that they could let go and then touch again as occasion wanted, connect and disconnect. This view arose when the old anatomical idea of fixity of brain-paths was shaken by the concept of a 'synapse', a cell-contact capable of transient alteration. The unclasping of hands, the temporary withdrawal of contact, was to account for the change from conductivity to 'block' at the synapse. But the withdrawal could never be observed. The variable resistance at the junctions was accounted for without any gross motility of the nerve-cells.

A brain-cell is not unalterably from birth a brain-cell. In the embryo-frog the cells destined to be brain can be replaced by cells from the skin of the back, the back even of another embryo; these after transplantation become in their new host brain-cells and seem to serve the brain's purpose duly. But cells of the skin it is difficult to suppose as having a special germ of mind.

Moreover cells, like those of the brain in microscopic appearance, in chemical character, and in provenance, are elsewhere concerned with acts wholly devoid of mind, e.g. the knee-jerk, the light-reflex of the pupil. A knee-jerk 'kick' and a mathematical problem employ similar-looking cells. With the spine broken and the spinal cord so torn across as to disconnect the body below from the brain above, although the former retains the unharmed remainder of the spinal cord consisting of masses of nervous cells, and retains a number of its nervous reactions, it reveals no trace of recognizable mind.

That the brain derives its mind additively from a cumulative mental property of the individual cells composing it, has therefore no support from any facts of its cell-structure. For a classroom to exhibit an isolated brain-cell and label it large 'The organ of thought',* may be dramatic pedagogy; it is certainly pedagogical overstatement. The cell-organization of the brain may be the key to the secret of its correlation with mind; but not, it would seem, by individual mental endowment of its constituent cells.

On the brain, it is true, devolves the managing of those of our acts of which we are directly aware. Looked at along the evolutionary series the brain it is with whose development has progressed the control of those acts which we most directly control. In it are carried to their highest pitch the nerve-actions which manage the individual as a whole. It integrates the individual as a system of motor acts, and the integrated act is the response to an integrated situation, integrated likewise by the brain, but especially by mind.

We are back at the close tie between motor act and mind. We saw it was primitive. We see it here still operative although no longer primitive. Control of act and awareness of act meet. I cannot by any effort of my will evoke my knee-jerk. Likewise I do not directly experience it. When it is elicited I seem to look on at it, as I might at a motor car moving. It is not so with my hand sketching; I do control its act and do directly experience it acting. My experience then is that it is 'I' doing the drawing. If I am told, as indeed science tells me, that I, as mind, have had nothing to do with this act of drawing except as an on-looker, I find that puzzling.

The dilemma goes further. The motor behaviour of the individual is our only contact with his individuality. Indirect indication of him though it be, we in that way interpret him and allow him 'values', moral, aesthetic, etc. We infer he will do a generous act because we have inferred of him a generous mind. We attribute his acts to his mental character which we have inferred from his acts. We even fancy that our mental opinion of him can influence our own motor behaviour toward him. I have come to regard my words as an outcome of such thoughts as I have. When I ask science to tell me how all this is so, science vouchsafes me no reply. If I ask again she tells me it is none of her business; that though spoken words are energy, thoughts are not.

* I met it in Prof. W. Waldeyer's class-room, Berlin.

Traced along the animal series the roof-brain has evidently spelt success. From small beginnings it has become steadily a larger and larger feature of the nervous system, until in adult man the whole of the rest of the system is dwarfed by it. In man it shows unmistakable asymmetry. Man is a tool-using animal and tools demand asymmetrical acts, acts which at the same time are attentive and unified. Man has led a tool-using life for, some say, the better part of a million of years. Most of his tools are of right-handed use, even far back in times almost pre-human. The left-side brain is concerned with the right-side hand. The human brain's left half predominates; and speech belongs to that half of it.

The climax of mental integration would seem to be 'attention'. If we would parallel mental integration with motor integration 'attention' seems to counterpart in mental integration the skilled act of motor integration. Our inference therefore is that in the integrated individual they will go together. The 'willed' act is but a culmination of attention. Where is an instance of completer solidarity in a complex organism than a man intent and concentrated upon some act of strenuous 'will'? But the willed act in man presents itself notably in two forms. It may lay under contribution the whole muscular system of the body and every channel of sense. Or it may well-nigh forgo muscular action and well-nigh exclude every channel of sense. This latter kind of integrated act is practically man's alone, as in pondering a problem. The anthropoid primates have not it. But can we imagine man, even primitive man, without it? Rodin's statue portrays prehistoric man erect with hand to forehead essaying abstract thought. His too is that other statue, seated, the 'penseur' absorbed in abstraction. There are, in the wholly infra-human, poses which do at least suggest reflection. There is our dog's quizzical little twist of head when he would divine our meaning. I have seen an orang too whose facial wisdom and contemplative repose gained him the name 'Philosophy'. But his was I think an inertia perhaps bred of carefree captivity. Primitive man's obstacle was not inertia. His activity strewed continents with litter of its industry. The infra-human scarcely has an 'industry'. It has climaxes of will, as for instance in some torrential rush of capture or escape. On the other hand man's will intent on a mental problem may, except for the taking of breath, forgo the movement of a muscle. For the infra-human only the one mode of climax is possible; for the human both. Yet it is artificial to separate them. To separate the one as 'action' the other as 'thought', the one as physical the other as mental, is artificial because they both are of one integrated individual, which is psycho-physical throughout. A psycho-physical σύνολον or 'tout ensemble', whose history is one history. Nature has dealt with integrated act and integrated mind together; has fostered them together, as a united growth. One tie between them is concurrence in time and collocation in the brain; another is that both compass the same end.

Time may be an invention of the mind, but none the less the mind is integrated by it. Combination of action spatially, for instance by conducting nervous excitations to the same place, is not the brain's only means of integration. It employs, as well, simple conjunction of activity in time. The motor individual as such is, we saw, a well-knit unitary thing. Two parts of it which are capable of separate excitation, brought into co-ordinate action concurrently, compose, *qua* parts of a unified mechanism, an act as integral as if one single centre brought them into play. Standing is a highly integrated act. But reflexly it is a patterned manifold of reaction to a stimulus made up of a thousand concurrent stimuli. There is no focal 'centre' for 'standing', any more than there is the old-time 'centre for equilibrium'. Conjunction of activity in time relieves demand for concentration in space.

Turning from the motor with its unity to the mental with its unity, there too simple concurrence in time again accomplishes synthesis. Our momentary 'now' at every time of the waking day is, though a complex experience, unified in virtue of the contemporaneity of its items. We can feel assured, thinking of the brain-mind correlation, that where spatial conjunction of action by the brain is unneeded it is not likely that cerebral structure providing it will be found. The brain will be the simpler for that. We customarily do our seeing with both eyes. To shut one lessens the entrant light, the physiological stimulus, by one-half. Does it make perceptible difference to the brightness of what is seen? Even the nuances of light and shade remain practically unaltered. Again, suppose a contour presented to the one eye along with no detail to the other. The contour asserts itself binocularly as though unchallenged by denial of its presence in the corresponding other field. Physiological summation would not behave thus. These are psychical integrations worked by contemporaneity.

A light shown and shuttered at frequent interval flickers but becomes steady to appearance when the alternation is more rapid. Then light-phase follows light-phase before after-sensation has perceptibly declined. This is the principle of fusion of the motion-pictures at the cinema. The brighter the pictures the more frequent must be their succession to kill flicker. Suppose for our observations a little disc illumined each time the window of a cylindrical screen spinning in front of a lantern allows passage of the light. Spinning the screen faster or slower controls the flicker. Flicker will disappear at an alternation of about 60 per second. We look at the disc with our two eyes. We have a right eye image of the disc and a left eye image but we see only one disc. That is the well-known 'singleness' of binocular vision. Congruent images from corresponding retinal points give one single image to the mind, a single mental image. This has often been taken as evidence of central conjunction of the nervous mechanism of the two retinal points. Thus, as meaning a single nerve-fibre which forks into a branch for each optic path, or twin fibres from one and the same cell in the brain, or central confluence of the two nervous reactions right and left to 'a common physiological centre' or 'point'.

By arrangement of the rotating screen the twin points of right and left eyes can be excited in either of two ways. The excitations *R* and *L* can be made synchronous or alternate. When the former, on any of the suggestions just mentioned of confluence of the physiological response to a common mechanism, the two excitations must sum. With the other, the alternate, plan the phases of excitation of one retina will fill the intervals between excitation of the other retina. On the suggestions mentioned above, namely, central confluence of the excitement to a common physiological mechanism, the frequency of excitation of the common mechanism will by the 'alternate' plan be double that by the synchronous plan, and each excitation of the series is less than in the synchronous method because it is unreinforced. Both these latter conditions will, on the hypothesis of a central mechanism in common, reduce the rate of spin of the shutter required to kill flicker of the disc binocularly observed under the 'alternate' plan. But experiment finds that the rates required to kill flicker by the synchronous arrangement and the alternate arrangement differ hardly or not at all.

There is thus no evidence that the nervous paths from two corresponding retinal points *R* and *L* reach a common mechanism in the brain. The corresponding right-eye and left-eye perceptions are however contemporary. Their contemporaneity fuses them. There is here no need of spatial coupling in the brain. The right-eye and left-eye perceptual images each observed singly do not perceptibly differ. They belong to 'corresponding visual points', that is, are both referred to the same 'place', besides being indistinguishable otherwise. Each of them 'means' for perception the same thing. The mind, concerning itself with meanings, accepts these visual images as being one and the same visual thing at the same 'there' and of the same 'now'. If, because this 'same' given thing at the same 'there' and 'now' is reported to it contemporaneously by two channels of the mind, the mind interpreted the experience as two-fold, that would be a pragmatic misreading of its 'world'. That it is not so misread shows that the nervous channels themselves are no part of experience; the mind does not experience them at all. That the conjoined reports are not misread indicates their conjunction is mental, not physical. It is not therefore a physiological conjunction in space but a temporal conjunction in 'mental' space. It is not spatial conjunction of cerebral mechanism which combines them. Identity in time and in perceptual space suffice. It instances the 'now' as an integrating factor of the finite mind.

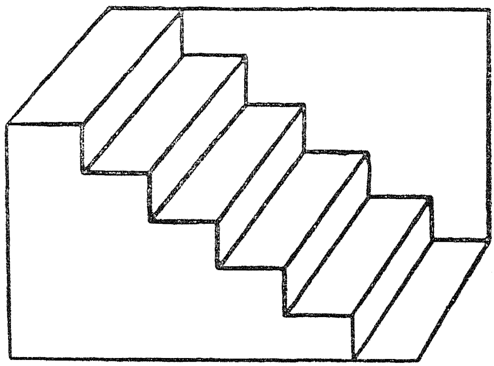
It is much as though the right- and left-eye images were seen each by one of two observers and the minds of the two observers were combined to a single mind. It is as though the right-eye and left-eye perceptions are elaborated singly, and then psychically combine to one. The synthesis is a mental one in which the finite mind uses 'time' as synthesiser. We know too that the mind is actively operative in the synthesis. We can take an instance where the two components *R* and *L* differ perceptibly; their synthesis on contemporaneous presentation still occurs. With difference in tint between the right- and left-eye percepts the synthesised percept which results binocularly is of intermediate tint. The red and green postage-stamp thus combined is perceived as sheeny bronze. Contemporaneity here finds the percepts no merely passive material but active on each other. They interact with the result of compromise between the two. So similarly with uniocular points right and left not 'corresponding' and yet not too disparate to fuse binocularly. Integrated binocularly to a single point that point is 'seen' on an axis intermediate between the axes of the component uniocular points, and it has 'depth' along that axis in proportion to the disparation of the component points. Simultaneity of presentation of the percepts gives occasion for these syntheses, and, over and above that, the percepts are active on one another, for they modify each other. And percepts are 'mind'. In short the mind integrates the two to a unity not different from either component when the two components are not noticeably dissimilar. And when the two components are noticeably dissimilar they are fused to a compromise between the two. The two components can be so dissimilar as not to fuse. They then alternate in consciousness. In all this there is no evidence that the mind-brain correlation requires in any of these combinings the brain to provide spatial conjunction of the two component processes. All that is wanted is their concurrence in time.

The two eyes are here like two observers, who where their two views differ not beyond a certain amount decide to agree by splitting the difference. If the divergence of meaning is beyond that amount, the one view suppresses the other, turn and turn about. We arrive at a notion that for each eye the sensorium, to use a conveniently vague term which yet seems not too vague, carries elaboration of sub-perceptual and perceptual vision to a considerable pitch of mental completeness without marked collaboration between the visual processes of the two eyes. It is as if each eye had a separate sensorium of considerable dignity proper to itself, in which mental processes based on that eye were developed up to even full perceptual levels. Such would amount physiologically to a visual sub-brain. There would be two such sub-brains, one for the right eye and one for the left. Contemporaneity of action rather than structural union seems to provide their mental collaboration.

Are there thus quasi-independent sub-brains based on the several modalities of sense? In the roof-brain the old 'five' senses instead of being merged inextricably in one another and further submerged under mechanism of higher order are still plain to find, each demarcated in its separate sphere.

How far is the mind a collection of quasi-independent perceptual minds integrated psychically in large measure by temporal concurrence of experience? Its separate reserves of sub-perceptual and perceptual brain, if we may so speak, could account for the slightness of the mental impairment following on some brain injuries. Thus, the slightness of disability following destruction, or developmental failure, of the great commissure between the two halves of the brain. Simple contemporaneity can conjoin much. Provision of the roof-brain with collections of perceptual apparatus in duplicate, right and left, along with the tendency for circumstance to employ either the one or the other the more, would allow and make for asymmetrical development. Education, informal and formal, would stress one or the other. Observation finds mental inequality of right or left brain in man, and the naturalist discriminates man as the tool-using animal; he was already right-handed, i.e. left-brained, 200,000 years ago. And he is left-brained in his thinking, that is, his roof-brain of the left side seems to count much the more in his knowledgeable thinking. Right-handedness with its seat in the left-side roof-brain seems to carry thither with it 'speech'—of all motor behaviour that most closely tied to 'intellect'. The left-side roof-brain thus becomes further the seat of language. Henry Head has shown how along with this, in the right-handed person, perceptual appreciations generalize. In the right-side roof-brain they attach to a particular field, e.g. of the left hand, but the corresponding perceptual appreciations in the corresponding part of the left-side roof-brain are not thus confined. In this latter, destruction (by disease or accident) brings impairment not only of the perceptual appreciations by the right hand but impairment of such appreciations in general. After left-brain destruction the perceptual relations, be they visual, auditory or tactual, lose their meaning for the mind. The surgeon dealing with a tumour difficult of access within the brain knows his knife may sacrifice the right-side roof-brain with an impunity from mischief which he could not hope for were he so to treat the roof-brain of the left-side.

The mental 'now' is a unity, because whatever its items they conjoin to one significant pattern. That unity helps to construct time for the finite mind; a serial 'now'. To think of time as unifying the experience of the moment makes of time an integrator of the mind; but the unifying by the mind of its experience of the moment can no less be taken as an integration



by the mind of 'time'. That unifying of the experience of the moment is an aspect of the unity of the 'I'. There are the psychological figures, called equivocal because at one moment they look one thing, at another another. While looked at their 'meaning' unaccountably changes; what is being looked at as a set of steps suddenly without warning becomes an overhanging cornice.* But it is always the one or the other wholly. Is it to over-simplify to liken to that the mind's interpretation of its 'now'—always a situation with a single meaning? It is an integrated experience which is one situation at a time. Just as the integrated individual, even for those who regard the individual as a machine, is a machine which can do many things, yet a machine which at any time does but one main thing.

* The change is favoured by rotating the page to right or left while looking at the figure.

In the working of the body, e.g. in a muscular act, where the action of one part has to call up that of another which otherwise would not co-operate, or has to suppress that of another which otherwise would interfere, the nervous system provides actual spatial connection between them, and the brain takes part in providing it. That is the significance of the 'principle of convergence' which the arrangement of the nervous system so richly displays. The convergence of the nerve-paths broadly taken falls into two sets. In one set the convergence is outward, thus toward the centre which operates a muscle, putting the muscle at the disposal of many parts all of which can use it. It might have been thought such convergence as that was all which was needed. But there are still more voluminous sets of convergent nerve-paths in the opposite direction, namely, toward the brain. These are converging toward the 'place of mind'.

We might imagine this principle pursued to culmination in final supreme convergence on one ultimate pontifical nerve-cell, a cell the climax of the whole system of integration. Such would be a spatial climax to a system of centralization. It would secure integration by receiving all and dispensing all as unitary arbiter of a totalitarian State. But convergence toward the brain offers in fact nothing of that kind. The brain region which we may call 'mental' is not a concentration into one cell but an enormous expansion into millions of cells. They are it is true richly interconnected. Where it is a question of 'mind' the nervous system does not integrate itself by centralization upon one pontifical cell. Rather it elaborates a million-fold democracy whose each unit is a cell.

The notion of the cell as, even in the many-celled organism, a unitary life, is documented by physiology in problem after problem. Secretion, muscular contraction, gas-transport, tissue-respiration, metabolism, these and a score of other processes all lend themselves to interpretation as additively operated by communities of individual cell-lives. The liver-cell is a miniature liver; the muscle-cell a miniature muscle. The cell transplanted from the body can be cultivated outside it in suitable soil, as can a plant. Growth in ourselves is similarly additive, a cellular multiplication. The impetus to reproduction is conjugation of one separate cell-life with a second separate cell-life. The interpretation of the single cell as a unitary living thing is clinched, so to say, by the germ-cell. In size the virus-particle takes us to a still smaller separate unit of life. Thus the concrete life compounded of sub-lives reveals, although integrated, its additive nature and declares itself an affair of minuter foci of life acting together. This holds too of the nervous system even where most integrated. Transit along nerve-paths is marked by changes in speed and potential at the points where the component nerve-cells meet. The nerve-chains although conducting in continuity are still composed of self-centred cells.

When however we turn to the mind there is nothing of all this. The single nerve-cell is never a miniature brain. The cellular construction of the body need not be for any hint of it from 'mind'. Despite the all-or-none character of the nerve-impulse, the mind exhibits no 'structural grain'. Is there a suggestion in the scale of sensation-increments or thresholds? Doubtfully. A single pontifical brain-cell could not assure to the mental reaction a character more unified and non-atomic than does the roof-brain's multitudinous sheet of cells. Matter and energy seem granular in structure, and so does 'life', but not so mind.

A good anatomical museum exhibits the type-forms of our own stock, the vertebrate series, set out in a vista to show how evolution has treated us. That useful critic, the naïve observer, following the series, is likely, remembering how much of the world escapes our senses, to feel surprise that the traditional 'five' senses have, throughout our evolution, just remained at 'five'. The museum exhibits to him man at top of the nervous scale with the same nominal 'five' as had the fish. Our naïve observer would have expected at least an additional sense-organ, say for electricity. It might, he may feel, have had now its opportunities in domestic use. In short he would have expected evolution in its course to have supplied us with more various sense-organs for ampler perception of the world. We tell him that evolution does not cater for scientific curiosity about the universe. It is not idealist; its concern is that each life may get a living. The 'five' senses enable that. We can tell him that, none the less, 'sense' has progressed since its primordial days.

The policy has rather been to bring by the nervous system the so-called 'five' into closer touch one with another. A central clearing-house for sense has grown up. The primitive brain did little toward combining the sensa of the separate senses. That is known because in the primitive brain the actual anatomical channels of sense find their way very scantly to any common rallying points. Aristotle, though he missed the brain as being the mind's chief organ, yet argued that an internal place of coming together of the channels of sense must be a feature of the organ of mind. Nature herself was perhaps slow to seize that principle. 'Trial and error' is often slow. The integration of this sense with that sense has helped to implement both. Not new senses but better liaison between old senses is what the developing nervous system has in this respect stood for.

Correspondingly in the development of motor acts the old motor apparatus persists little amplified throughout the vertebrate stock. The old gamut of muscular acts is not greatly increased except finally as speech. What new organization effects is that each item of the old set of muscular acts is placed at the disposal of more various incoming demands, both those from the world around and those from the world within. Each motor act in that way becomes the servant of more masters. The old motor act is in effect turned to new purposes. The old paw met fewer demands than does the newer hand. In this re-integration the roof-brain takes a leading part. It puts new 'subscribers' through to motor acts not previously theirs to call up. To make the new connection the new call has only to precede closely and for a few repetitions a call expected from an already empowered caller. The fresh connection is thus established.

This enlarges the scope of motor behaviour. It is a learning of new ways. The training of animals follows this course. The training may be given by a trainer, or by the circumstances of Nature. It is education either way. The forebrain can be educated. Before it truly there were, and besides it too there are, other educable systems in the nervous system. But this, of the roof of the forebrain, is in man so educable as to be practically a new thing in the world. Man, said Francis Galton, is the educable animal. In the dog new behaviour can be established in a few repetitions, and linkages can be combined even to the third degree. In man it seems they can develop almost without limit. The new connection, thus acquired, under disuse disappears but with use it improves; it becomes a habit; habits are however not heritable.

Leaning upon the physicist the physiologist has finer means now than ever before for asking the ways and doings of the brain. Electrical technique enables him to detect happenings in the brain which formerly he could not, and in that very part of the brain which evidence bespeaks as having correlation with the mind. One approach to the correlation might be minute enquiry into the character of the energy processes detectable in the living brain, especially the 'mental' part of it. Changes of temperature might serve the purpose, but they are slight and little accessible to examination. Again, chemical study though as successful as any in getting at the inner processes of life is at a disadvantage in the brain. Chemical search cannot usually be made without disorganization of the very substance it would examine. Chemistry cannot at present in its examination of the brain pay regard there to cellular arrangement, though that must be a datum for the ways of the brain's doings.

Chemistry does show that the roof-brain is especially sensitive to changes in the oxygen-tension in its fluids, or, less technically, to the pressure of its oxygen supply. In the pigeon suffering from beri-beri, along with dramatic relief of its symptoms by vitamin B_1, runs dramatic improvement of the impaired respiratory process in the brain (Peters). The roof-brain is more sensitive to shortage of oxygen than is the brain elsewhere. Such shortage impairs mentally as well as physiologically. There is disturbance of thought and derangement of ideas. Barcroft, in the High Andes, observed disaptitude for arithmetic. Glucose, the typical physiological sugar, is urgently important to the brain. It is the brain's usual fuel. The brain draws it from the blood. It does not, as do some organs, take it into storage. It takes it to use it at once. Judged by its chemical turn-over the brain is not a homogeneous organ any more than it is as judged by its microscopical structure. In the roof-brain or cortex the need for oxygen is greater than in nearly every other part. Narcotics diminish the oxidation of sugar by the brain. The greater the narcotic power the more the interference with the brain's oxidation. When the quantity of sugar supplied to the brain by the blood-stream is less the oxidative turn-over is less owing to the lack of oxidative food. Without vitamin B the brain cannot make proper use of glucose as a food. With shortage of sugar the working processes of the brain suffer. Thought and behaviour alter. If the conditions be prolonged, unconsciousness ensues, and if prolonged further the brain-cells are permanently damaged. But if not so prolonged when the normal supply of sugar is restored the brain-cells recover and thought and behaviour again become normal. In this light, mind is a function of the chemistry of the roof-brain.

It is however by electrical means that the activity of nervous organs can be most intimately followed. Electrical potentials indicate nerve activity closely and quickly. The nerve-impulse—the process by which universally, and perhaps exclusively, nerve-cells communicate one with another—seems in essence electrical. Travelling impulses of less than a thousandth of a thousandth of a volt and lasting, as they pass any spot, one/10,000th of a second only, are photographed or seen or listened to, and in their almost undistorted time-relations. They are fleeting and self-mending electrical leaks which move along the skin of the nerve-thread. Intensity of action does not increase an impulse but sets up successive impulses more quickly. The upkeep of the membrane ready for transmitting impulses is an activity as is the impulse itself. When therefore we speak of a nerve or of the brain as being at rest in the sense that nervous impulses are not travelling it, the expression 'at rest' stands simply for another and a steadier activity. The disturbance which we call 'action' can be thought of as rhythmic, and rhythmic at different rates. The activity we identify with rest is a balanced activity, a dynamic equilibrium, which can maintain itself. Its upset, which is 'action', is not an equilibrium, it cannot be maintained long. It spends a reserve which will have to be made good. It brings in its train 'fatigue'.

It may be objected that it is not nerve-impulses which are likely to tell us what we want to know of the brain. They are a concern of nerve-fibres. Nerve-fibres are merely the wires to and from the telephone-exchange. We want the activities of the exchange itself. Activity of the brain involves great numbers, not to say, vast numbers, of nerve-cells co-operating. Yet the means of securing that co-operation is by impulses via the nerve-fibres connecting cells. A large and an essential part of even the highest brain activity must therefore consist of nerve-impulses.

We turn to the actual cells of the brain. They, if we pursue the simile of the telephone system, are not the mere wires but are the actual exchange; they do the retransmitting. They too have now come under examination by electrical methods. Their changes of potential are of two kinds; the more usual fall and an opposed rise of potential. Since in these situations the neural process is known to be of two kinds, one activation, the other arrest of activation, these changes of opposed electrical sign suggest a significant fit into the physiological picture. And there are too, as we saw, the rhythmic electrical waves which can be picked up by pad-electrodes placed on the head. They come probably from the surface-sheet of the brain cells. The rhythm of the beat is not too quick to be easily distinguishable by us were it perceptible to our consciousness at all. But our consciousness knows nothing about it. Through all the ages no suspicion of it has dawned upon us. Not even when now told of it do we feel it. The seat of the rhythm is in the visual region of the brain; vision sees nothing of it. Yet with a shift of mind the beat is altered; to open the closed eyes immediately disturbs it. It is possible to upset the rhythm by trying, without opening the eyes, to see something. A flash of light on the eye and a whole series of waves can be picked up from the visual part of the brain.

Physiology has got so far therefore as examining the activity in the 'mental' part of the brain when activity there is in normal progress. The desideratum to carry observation into the telephone-exchange itself with that exchange normally at work seems thus at last fulfilled. But has it brought us to the 'mind'? It has brought us to the brain as a telephone-exchange. All the exchange consists of is switches. What we wanted really of the brain was, it would seem, the subscribers using the exchange. The subscribers with their thoughts, their desires, their anticipations, their motives, their anxieties, their rejoicings. If it is mind we are searching the brain for, then we are supposing the brain to be much more than a telephone-exchange. We are supposing it a telephone-exchange along with the subscribers as well. Does our admirably delicate electrical exploration vouchsafe us any word about them? Its finger is ultra-sensitive, but energy is all that it can feel. And is the mind energy?

The 'subject' whose eye opens and whose brain-waves then alter, experiences as the most significant fact of the moment the mental change that he now sees something whereas before he did not. Do the concurrent electrical potentials contribute anything at all to the conception of, or to the understanding of, this visual experience?

It is now some seventy years since the words of a great biological leader of his time to his hearers were "the thoughts to which I am now giving utterance and your thoughts regarding them are the expression of molecular changes in that matter of life which is the source of our other vital phenomena" (Huxley). The terminology is a little 'dated', but is the main position thus set forth altered today? The concomitance in time and place between the 'molecular changes' and 'the thoughts' is still all we have correlating the two. Regarded as a paradox it has become more intriguing; regarded as a gap in knowledge more urgent.

It has its practical consequences. One is that in the training and in the exercise of medicine a remoteness abides between the field of neurology and that of mental health, psychiatry. It is sometimes blamed to prejudice on the part of the one side or the other. It is both more grave and less grave than that. It has a reasonable basis. It is rooted in the energy-mind problem. Physiology has not enough to offer about the brain in relation to the mind to lend the psychiatrist much help. It has occupied itself largely with what are called the lower levels of nervous action. Results of general value have emerged. The nature of the nerve-impulse, the properties of cell-contacts as one-way gates compelling one-way traffic on nerve-paths, the occurrence not only of action but of active suppression of action, the knowledge that intensity of action means not larger impulses but more frequent impulses, that impulse-effects can sum, or cancel, that there are places where impulses spontaneously arise. Much of this knowledge certainly applies to the brain, and to that part of it which interests us here, the roof of the forebrain. Every nerve-cell of the millions in it is clearly at a glance a nerve-cell. But nerve-cells as a class are elsewhere not specially concerned with mind. It is partly conjecture whether the properties of all these nerve-cells, their fibres, their cell-contacts (synapses), their cell-bodies, have rigidly those characters observed in the more accessible nerve-cells of the spinal cord and elsewhere. That the properties will not differ fundamentally from those elsewhere seems safe to suppose.

Were for instance the one-way traffic along nervous paths which obtains in the spinal cord not to hold in the case of paths in the roof-brain, that would allow new possibilities of interaction which our present interpretation does not bargain for. But the visible concatenation of the cells as studied by the microscope does not hint that if one-way traffic obtains in the spinal cord it is departed from in the roof-brain.

In one respect the highly specialized nerve-cells most studied, those of the spinal cord, fail as a type of nerve-cells in general. Their specialization for reflex action has reduced to vanishing point the feature of self-excitation. The rhythmic volleying of cell-groups in the roof-brain may be such self-stimulation. But self-firing in itself gives no presumption for correlation between the roof-brain and mind. The roof-brain cells, whether because the latest and so less stereotyped in their ways than others of hoary ancestral tradition, are more plastic and open to modification than the old. They can attach old motor acts to fresh unwonted calls on them. They can acquire new habits. Then, as counterpart to that, if we pass over to 'mind' they compose the organ which *par excellence* can learn.

Nature is a great teacher. But for teaching there must be learners. A certain proportion of what we call living nature can learn. What is commonly called the survival of the fittest turns partly on the capacity of certain forms of life to learn. Not that what is learnt is inherited. But the ability to learn favours survival and is heritable. A vast number, perhaps the numerical majority, of animal forms cannot be shown unequivocally to possess mind. But none the less the student of their behaviour finds that while they 'seek' and prolong contact with some items of their surround, e.g. food, they 'avoid' or break off contact with other items, which, as the observer notes, would harm them. Thus, with the reflex action of the brain-less frog, a morsel of acidified paper wet with acid is pushed away (defence) by the mindless limb or the limb is withdrawn from it (escape). This class of reflexes which imply defence or escape are known as 'protective'. They are physical behaviour which in higher forms of life where mind is recognizable have mental accompaniment, and their mental accompaniment is 'pain'. The act and the pain then make one integral reaction—but they are still separable to experimental observation. Widely apart in evolutionary age they lie apart from each other in the nervous system, the one is spinal the other cerebral. In the spinal dog the limbs are insentient; yet, if one foot tread on a thorn, it is at once held up out of further harm while the other three legs run away. The protective reflex is there, but the little wound causes no pain, because it has no nexus with the mind. Again, in appendicitis, the muscles are characteristically tightened over the inflamed part; thus protecting it and keeping it quiet. This is a reflex contraction, so automatic that the patient cannot even relax it. It is quite separable from the pain, for ether inhalation will annul the pain by paralysing the brain long before it annuls the contraction.

The protective reflexes are innate. They afford a measure of protection to their individual beset by a world of danger and damage. They instance the psalmist's 'wisdom of the body'. Their service we may suppose has given them survival value. Where they are yoked with mind we know from our own experience that their sensual accompaniment is rich in affect, an acute psychical urge, in short 'pain'. This urge reinforces and amplifies the measure of protection and relief the pure reflex act affords. Being mental it develops the situation into a mental situation involving perception and affect and imbuing it with 'time' and 'space', the attributes of mind. This mental reaction, like the pure reflex it accompanies, is protective but comprising 'time' as it does it is not indefinitely of *any* moment as is the reflex. Its 'pain' brands it into the time-system of the finite mind as unpleasant and not to be repeated. It is a 'lesson'.

As we say, "the burnt child shuns the fire". The experiments of Thorndike and of Pavlov have shown how important this is in the methodology of training. It has a positive counterpart, training by reward, a seeking to repeat remembered satisfaction. The principle enters into our own education, formal education as well as natural and social.

Here our contact with it turns merely on two points. One is the practically universal distribution through animal life of a special set of receptor organs whose sole scope is that of making the animal react to infliction of physical injury, and making it react either by 'defence' or 'escape'. This shows us that extraneous injury to life is taken by Nature as part of the normal routine of life. This special set of so-called 'noci-ceptor' organs, which evokes protective movements, seems more widely broadcast in the animal series than is recognizable mind itself. It is found in animal forms where there is no evidence of mind. In animal forms however which partake of mind its noci-ceptor organs pertain to sentience, and provoke 'pain'. Physical pain is thus the psychical adjunct of a protective reflex. The only modality of sense which the noci-ceptor organ evokes is pain. Other of our sense-organs evoke their modes of sensation—sight, hearing, touch, cold, warmth, smell, bitter, sweet, and so on—without 'pain', but these injury-organs provoke pain and nothing but pain. They are pain-organs and are called so.

Their specific stimulus is, in the narrow sense, not specific at all, but in the biological sense it is specific enough. It is anything which does injury to the part it reaches. The little pain-organ so to say watches over the part at and immediately around where it is situate. Pain therefore is in the evolution of mind treated and provided for as part of the normal economy of animate nature; further it is the more developed the higher its organism in the scale of mind. It does not require much study of the pain-organs and their arrangement to show that the infliction of injury which they envisage and react to is in vast preponderance injury inflicted by other species of life. The infliction of injury by one species of life upon another is therefore treated by Nature as part of Nature's normal scheme.

Evolution has thus supplied the body with a special sense of its own injuries, a sense so drastically affecting the mind as to capture the mind's attention even to exclusion for the time being of all else. The development of this pain-sense has the interest that it illustrates the evolutionary process dealing with the mental side of the organism as effectively as with the material side. For all the evidence we have evolution draws no pragmatic distinction between the two. A mental event, pain, superadded to a reflex, the protective reflex, seems here to reinforce and amplify the physical act. The local reflex itself affords its limited protection and relief, e.g. by holding the part taut and quiet. But the 'pain' through the mind can enjoin keeping the whole body motionless though tense. In ourselves, social and sophisticated, it may provoke the train of action of 'calling in' the doctor. In short, under the rubric 'pain' we meet mind moving matter to help mind in mind's distress. Mind invoking the body to do something and, in spite of the eternal psycho-physical difficulty, effectively. 'Pain' seems to pay no heed to that old dilemma. My raging tooth drives me to the dentist as if it operated my motion thither.

The roof-brain is the nervous organ which *par excellence* can learn by experience. One structural feature of it is so pronounced that, as a dry fact, it is impressive. Its cell-population is enormous. The numbers in our own brain-roof run to ten thousand millions (Judson Herrick). To microscope this nerve-mass is to be struck by a seemingly reckless profusion of nerve-cells. It is the reason of the greater size of the higher types of brain. In the dog it is larger than the whole of the rest of the nervous system taken together. In ourselves the relation is hugely increased further. It is out of all proportion to our bodily bulk. As old Laurent Joubert said in his picturesque way* the brain of a man is larger than the brains of two oxen together. In the bygone geological world some of life's ancient shapes attained bodies 100 feet in length; but they had a forebrain not larger than a nut. Our forebrain is so large as to bulge out the contour of the head. Our brain is a monster brain. It gives the ball-like top-end of us. Aesthetic or not it is an overgrown nerve-ganglion protected by a bony case. Our sophistication and prejudice may regard it as a thing of beauty. It symbolizes our prerogative, human mind, and in common belief contains it.

* *Traité du Ris*, Paris, 1579.

Of three aspects of mind broadly distinguishable, the affective, conative, and cognitive, one inference perhaps to be drawn from the human brain is that growth of cognitive processes makes wholesale demand on numbers of nerve-cells. We can understand how this might be if a principle such as the 'association' of old-time psychology be largely engaged in it. An automatic card-index on an enormous scale with copious cross-references may be asked for. This part of the brain is evidently cumulative in time. And so is knowledge. May it not be that there is a correlation between the two? Again, where intellectual activity is required it is as though a pressure-reservoir were kept at hand. This great many-celled spongework in the human roof-brain is something like a continuum from end to end furnished with perhaps a million discharging mouths. It might well provide reinforcement, and reinforce vicariously as occasion requires here or there. The cerebellum was once thought a reservoir-organ for reinforcing the motor powers of the cerebrum. Apart from that restricted strip whence electricity can evoke bodily movement, by far the greater part of the roof-brain is, as the phrase goes, 'silent', that is in response to electricity yields nothing detectable at all. There is the psychological theory that a general factor, *g*, enters into mental ability. Of this Spearman its author tells us that a permissible picture of it is as a 'power' which can be supplied to the mental factory from a general power-station and distributed to any required particular engine. Lashley would perhaps identify *g* with a 'mass-action' of the cortex of the brain.

The neural basis of affect we can suppose need not entail much neural superstructure. It might use chemical reinforcement. This lets us stress the roof-organ of the forebrain as especially cognitive, with below it the old kernel-organ of the forebrain especially related to 'affect'; and we remember that every cognition has, potentially at least, an emotive value; emotive, and, along with that, conative effort as a further factor. How do they hang together? What is the significance of their so doing? Not in man alone but infra-humanly in due degrees, no doubt less cognitive. What is the tie which conjoins these several aspects of mind so inseparably? What is it else than 'urge-to-live'? Human cognition may like the winged horse take at times its flights toward the stars and forget earth. None the less it is harnessed to life's car, whose charioteer is 'urge-to-live' sublimed to 'zest-to-live'. It and its fellow-steeds, endeavour, will, emotion, passion or whatever else we call them, pull under the same lash.

The student of the mind, for instance the practical psychiatrist at the mental hospital, must find the physiology of the brain still remote and vague for his desiderata on his subject. He may have hoped from it some knowledge which would serve to found the norm from which psycho-pathology could take its points of departure in this direction or in that. There is for instance the condition 'anxiety'. None is I suppose more far-reaching as a warper of the mind. But where does neurophysiology contribute anything to the knowledge of the norm from which anxiety causes departure, and what has cerebral physiology to offer on the whole subject of 'anxiety'? The psychiatrist has perforce to go on his way seeking things more germane to what he needs. The mind is a something with such manifold variety, such fleeting changes, such countless nuances, such wealth of combinations, such heights and depths of mood, such sweeps of passion, such vistas of imagination, that the bald submission of some electrical potentials recognizable in nerve-centres as correlative to all these may seem to the special student of mind almost derisory. It is, further, more than mere lack of corresponding complexity which frustrates the comparison.

The mental is not examinable as a form of energy. That in brief is the gap which parts psychiatry and physiology. No mere running round the cycle of the 'forms of energy' takes us across that chasm. Perhaps that is what William MacDougall* was meaning when he exclaimed, "medicine has nothing to learn from psychology nor psychology from medicine".

The question of the relation between the working of the brain and the working of the mind is, we hear often, one improper to put. It is 'by nature insoluble', 'ignorabimus', 'the data at the present time are insufficient', or it is not of practical importance. The cogency of these grounds depends, I would

* *Brit. Med. J.* April 1939.

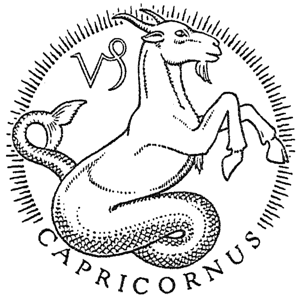
think, partly on the purpose for which the question may be asked. To put the question may serve as we have said "pour préciser les idées". And to do that may have urgency. Witness the training of the psychiatrist and the physiologist. Only *after* the question has been discussed can they go on their respective ways, as perforce they ultimately must, disappointed it may be, but wiser, if sadder, practitioners and men.

In such an impasse it seems permissible for the man in the street, such as myself, to outline to himself briefly, although he can do so but naively, the position. I would feel he is almost called upon to do so. The busy everyday world ignores the difficulty. That however does not remove the enigma. It was easy for the old classical *a priori* materialism to run rough-shod over mind. It used the term matter without any scientific delimitation of the concept. It was a doctrine which knew far less and spread itself far more than does the scientific study of matter, or energy, today. What is the reply when to the student of energy, in other words to the follower of Natural Science, there comes today someone who asks, "Mind presents itself as thoughts, feelings, and so on. They are the outcome of the brain. The brain is matter, energy. Matter and energy can only be matter and energy. Therefore thoughts, feelings and so on are matter and energy. Therefore mind is matter and energy?" I trust I do no violence to the argument; I have no wish to do so. The reply by the follower of Natural Science of today, if I as a man in the street may guess it, will not be, even in trend, at all like that which Lucretius gave in a famous and vehement passage, about specially small and well-rounded atoms. Such materialism was merely a frame of mind. The materialist standpoint today is a scientific position. Its answer today is of a different order. As I surmise it, it would say: Thoughts, feelings, and so on are not amenable to the energy (matter) concept. They lie outside it. Therefore they lie outside Natural Science. If as you say thoughts are an outcome of the brain we as students using the energy-concept know nothing of it; as followers of natural science we know nothing of any relation between thoughts and the brain, except as a gross correlation in time and space.

In some ways this is embarrassing for biology. Biology cannot go far in its subject without being met by mind. Biology as its name says is the study of life. And biology is a branch of natural science. Natural science has studied life to the extent of explaining away life as any radically separate category of phenomena. The categories of living and lifeless as regards science disappear; there is no radical scientific difference between living and dead. Time was when to think and to breathe were on an equality as attributes of life. Now, living, so far as breathing, moving, assimilating, growing, reproducing, etc. amount to life, has by natural science been accounted for—some might say, 'explained'. There is nothing in them which does not fall within the province of science. They are chemistry and physics. But though living is analysable and describable by natural science, that associate of living, thought, escapes and remains refractory to natural science. In fact natural science repudiates it as something outside its ken. A radical distinction has therefore arisen between life and mind. The former is an affair of chemistry and physics; the latter escapes chemistry and physics. And yet the occurrence of mind—recognizable finite mind—is confined to a certain particular field of chemistry and physics, namely, that of highly integrated animal lives. 'Thinking', in this its limited field of occurrence, appears as a phase of living. If, as is practical, we continue to subsume mind under life, we have to distinguish it as an activity of life selectively and uniquely apart from the rest. The psycho-physical difficulty places us in the position of empirics as to much. By ways which may be judged roundabout, we find ourselves at length pragmatically alongside of general commonsense opinion. That may be taken either as sanity or superficiality or perhaps both.

Our sixteenth-century physician Jean Fernel would have smiled at this difficulty which presents itself to us. For him there is no difference between thought and the rest of living. The cause of the brain's thinking was for him the life-spirit in it. That spirit has the brain for habitation, its temporary dwelling. He would tell us that what his boat is for the time being to the mariner, such the brain is for the time being to this spirit. That the brain should obey and do what the spirit would he finds no more remarkable than that the boat obeys the handling of him who sails it. But we recall a railway-coach attached to its locomotive solely by goodwill between guard and driver and it did not arrive.

For Fernel there was duality but that duality created a situation of no difficulty. Its members, matter and spirit, combined in perfectly satisfying co-operation. Matter was the servant. Spirit, mind, was the master. Perhaps that was from the Phaedo, where we remember the soul rules, the body obeys. Today the duality is there; and combination is there, but the footing on which the combination rests, so obvious to Fernel, is for our enquiry still to seek. Perhaps the 'servant and master' phrase had in view an assertion of free-will. But where in nature shall we find 'servant and master'? Where our knowledge halts our description will resort to metaphor. Long will man's fancy deal with the tie between body and mind by metaphor and often half forget the while that metaphor it is. Regarding this problem will a day come when metaphors can be dispensed with?



X

EARTH'S ALCHEMY

I want . . . finally to enquire whether any signs of unitary purpose can be found in History.
W. R. INGE, *God and the Astronomers*, p. 125.

The fact of progress is written plain and large on the page of history; but progress is not a law of nature.
H. A. L. FISHER, *Preface to The History of Europe*.

Had I been present at the birth of this planet I would probably not have believed on the word of an Archangel that the blazing mass, the incandescent whirlpool there before our eyes at a temperature of 50 million degrees would presently set about the establishment of empires and civilizations, that it was on its way to produce Greek art and Italian painting. . . .
W. MACNEILE DIXON, *The Human Situation*,
Gifford Lectures, Glasgow, 1935–7.

X

OUR topic of last time asked if and how it is that our thinking is correlated with our brain. If Natural Theology argue from the facts of Nature to a Divine Scheme to which they may point, then that question seems germane to our theme. It lies at the threshold of human approach to the whole Natural Scheme. Especially does it do so when we occupy the viewpoint traditionally taken by the physician and the naturalist, thus by our physician-philosopher, Jean Fernel, and long before him by his master Aristotle, namely, that man is a part of Nature. Then man and his mind and their position within the natural scheme of which they are parts become factors of importance for man's interpretation of that natural scheme. To omit consideration of them would be to look at one side only of the human situation. That would be more than ever to have but a broken light in viewing the situation. Unaided human sight will at best compass but a corner of the scheme. There will be much to which man has not access. The distances are immense and he is near-sighted. He peers into a small patch and what he sees there he submits to his reason which after all is very newly hatched. What wonder if his conclusions be meagre and insecure. What wonder they are narrowly anthropomorphic. Such they must be. That indeed is to him perhaps their chiefest value at this present. Without that they would not yield him, we may think, the zest, courage, ambition, altruism, which they do, or to come to our point, the idea of the Divine.

A recent volume of lectures under this Foundation, in a sister University, has taken as its subject, and charmingly discussed, what it terms the Human Situation.* Nothing I have to say can vie with it in range or gift of portrayal. Its pages however in their phrase 'the human situation' call up to me the following as a feature of that situation.

Man, in commerce with nature and with his fellows, looking

* *The Human Situation*, by W. Macneile Dixon, Gifford Lecturer, Glasgow, 1935–7.

out from himself as from an observation post, has gradually reached a markedly self-consistent scheme of all which is perceptible to him. This it has taken him long to do. We may surmise that almost from his first beginnings as man he has been about it, at first without conscious aim, latterly with conscious aim. As conscious aim it has seemed the satisfying of an intellectual need. To some men at least the desire to obtain a unified conception of all which the manifold of the world presents was in itself a motive. But long before that, and aside from it, the need for further knowledge of the perceptible must have been thrust upon man and dashed against him, flogged into him from every direction of sense. There was an urge within him to know, but the external situation likewise drove him to try to know. If we may guess at evolutionary history the external drive had been a situation surrounding living things immeasurably long before man's coming. But the internal urge to 'know' was a new position which surely had not existed before man. Out of that position arose gradually from scattered origins, and with chequered progress, at first almost insensibly slowly, a wider acquaintance with the perceptible world. Man, social animal as he has been called, was no less significantly a tool-user, a tool-maker, and a tool-designer. He is an exploiter of his planet as all life must be. But of him in that capacity his tool-using is an especially human trait. The tool lent his exploitation a special character. And his exploitation reacted on himself. He grew to see that to exploit the world more successfully he must understand the world.

This perhaps, in very brief, has been his way of arriving at such account as he can give of the structure of the perceptible world, as he apprehends it. It is a description of things, of what they are and of what they do, and inferentially of what can or cannot be done with them. But it was the learning of this last which often came first, and opened up the rest. By pushing his analysis of the manifold far enough he has found relative uniformity underlying the variety. In terms of this he succeeds in bringing all the perceptible in the world under one self-consistent descriptive scheme.

This scheme, the making of which has been long on hand, is still in progress. Its progress has prospered more at certain times than others. It prospered notably in the brief period of the intellectual ascendancy of ancient Greece. It has done so again later, more than ever before, in the last 400 years. It has recently reached as would seem a noteworthy stage. It strikes the man in the street, such as myself, who have never been concerned with the making of it, as having become excitingly comprehensive.

It attains to a something of this sort. It starts with an elemental unit, an energy-unit, an ultimate packet of movement, so to say. As movement this in relation to another unit goes towards that other unit or away from it according as that unit is of this kind or of that kind. From a very limited number of types of such unit the scheme builds up a definite relatively small number of compound systems of specific kind. These minute systems are very permanent under terrestrial conditions; they were at one time regarded as ultimate particles, wherefore they were misnamed, after the old Greek fancy, atoms. They, in virtue of the arrangement of their constituent units, e.g. electrons, react together in definite various ways. For instance, they combine into those more complex and less stable, larger systems, molecules. Drawn up in accordance with factual observation of the perceptible this scheme embraces harmoniously the molecule, and the misnamed atom, and the more ultimate units from which proceeded the construction of those former. It is found applicable to the perceptible world in the entirety of that world. That is to say it finds the whole perceptible world amenable to description by it as 'energy' and able to be grasped by its conception of energy. It starts from a strikingly modest stock of postulates, certain 'charges' which 'attract' each other or 'repel'. By steps, which are checked against actual observation, it proceeds to examine all of the world which we can perceive. It finds in it nothing which cannot be described in terms of this scheme. The whole perceptible world is unified for us by this scheme. That world is, so to say, a manifestation of energy. Indeed it is describable as one great and manifold manifestation of energy.

Not for a moment is this conception to be regarded as a return to the old non-quantitative allegory sung by Lucretius, and sung with, in some passages, arresting power. That the term 'atom' taken over from ancient fancy into the quantitative argument of today is already a misnomer, illustrates the want of connection between the present and the old. But the reasoned argument reached today after centuries of patient toil, and unflinching rejection of all that perceptual observation, as judged by reason and experiment, did not confirm, has brought together an immensity, as being all of a piece. Earth, sky, sea, air, sun, moon, star, rock, plant, soil, animal, animalcule, and this our body and all its parts. Not only that but it is in terms of 'behaviour' that this same reasoned argument describes them. It describes all they *do*. That goes without saying because the ultimate term of its description is a 'doing'. We remember also that today's modesty—or its wisdom—sets 'to describe' over against 'to explain'. Our random list above, sampling the perceptible, this reasoned scheme therefore describes as 'doings'. It describes the behaviour of earth, sky, sea, air, sun, moon, star, rock, plant, soil, animal, animalcule, and of this our body and all its parts, as doings. It describes all their ways. Of all and each of them it describes the 'behaviour', and that is the doing, harmoniously throughout, because, resolving them each and all into the ways of units of like type, it finds them, taken together, to be one homogeneous system. All their acts are manifestation of a 'doing' or 'power' which it traces to be fundamentally of one kind throughout. I would not give the impression that the electrons, neutrons, atoms and so on at which this analysis of the perceptible world arrives are necessarily concrete objects. They may or may not be. Here they are physical symbols. They are, as Professor Dingle has said, postulates. It is only a question of degree between that and an 'act of faith'.

Perhaps, to be clear, I may restate of our theme here, so far as I see it, that the external world is by it taken purely as a world of perception, a perceptible world. A something given us by the mind served by its senses. Whether there be an external world over and above this perceptual world seems here beside the point. Not simply because that problem seems insoluble—discussion of the insoluble may bring items of interest. But whether the external world is, as the phrase goes, 'real' hardly presents interest for our question. 'Reality', 'ultimate reality', seems not to concern it. Here it is the perceptual world, and the concepts of it which are before us. Physical science analysing it with the purpose for one thing of examining its homogeneity, arrives at certain abstractions. These though they faithfully symbolize some of its actions bear small superficial resemblance to the everyday concrete world familiar to common sense. Electrons, neutrons, and so on are among these abstractions.

There rises to mind a memorable description by my distinguished predecessor here, Sir Arthur Eddington. He* gave an account of a table, his table, his scientific table. He described it in terms of this analysis we have now in mind. He described it with a gift and an authority which can shelter me. It consisted of "electric charges rushing about with great speed". It was composed of fields of force; it was dissectable utterly into electric charges. Modern physics "by delicate testing and remorseless logic" gave assurance that this his scientific table was *the* table. That is it was the table which he saw, leaned upon and wrote at, etc. The numerous electrical charges of which it consisted were sparsely scattered; yet it answered as a table. It did all that the familiar table does. Indeed it was the perceptible table, the perceptible table differently described. Though its ultimate constituents are sparsely scattered, he could, when he leaned his elbow on it, rely, he told us, on its support. A scientific elbow would similarly, as he told us of his table, be "chiefly emptiness". Coalesced to a single mass it would not be so large as this full-stop. Yet the elbow, as he said, would not pass through the table. The scientific elbow is likewise numerous electric charges sparsely scattered rushing about with great speed. On the whole more sparsely scattered than in the table. The analysis we spoke of has dealt with it, and found it not fundamentally other than the table, although in some and not unimportant respects it is different. If we say 'not fundamentally other' that depends on how deep a difference has to go to be considered fundamental.

The results of the analysis we are thinking of assures us by "delicate test and remorseless logic" that both table and elbow

* *The Nature of the Physical World*, Introduction, Gifford Lectures, given in Edinburgh, 1927.

are wholly electric charges. Chemistry and physics each in its own way endorse that. Going into detail they show us that the systems into which those charges are combined, the so-called atoms, although in both the elbow and the table they are of one fundamental type are not sampled quite similarly by the two. Turning to the next greater stage of complexity, molecules, these though a number are in kind common to both, show yet more divergence in the two cases. But still difference between molecules is but an affair of sharing electric charges.

True, there is between the elbow and the table the difference that the one is 'living' and the other is dead. Chemistry and physics say nothing of this. Or rather they say a great deal about it but do not in saying it make use of either of those words. If we tell them that the table was at one time living wood and is now dead wood, that the wood was at one time part of a living tree, they do not recognize the word as conveying any radical distinction between the two. Chemistry tells us that the table has such and such a chemistry now and that when it was part of the growing tree it had such and such another chemistry. But both were chemistry the one as much as the other. The same chemical principles are observed in both.

It is true there is less commerce now between the wood as table and the chemical field around it than between the wood as growing tree and that field. Less commerce with the air, no commerce with the soil. But chemistry says that neither in the one case nor the other does it find anything or any behaviour which is not chemical. Therefore chemistry prefers to describe the two cases in terms of chemistry. To call the one living and the other dead is, for chemistry, neither here nor there. The energy-concept finds itself equally adequate to both. Nor is there one kind of energy in the dead wood and another kind in the living tree. Turning to physics we get a like reply. Both describe the perceptible, whether living or dead, by the one energy-concept. The two disciplines together exhaust the aspects of the perceptible. The manifold of the perceptible is therefore unified by them, employing the energy-concept. In other words that concept gives a view on which the whole manifold becomes intelligible as just so many different combinations of action of the same units of action. Science has therefore in that way greatly unified knowledge.

A broad feature about its unifying scheme seems this. It sets out from the ascertained ultimate 'packet of motion' as we ventured to style it—the unit of doing—as unit. It proceeds to find the manifold a series of assemblies of such units. These assemblies are of different degrees of complexity. The least complex is the atom, a system whose behaviour rests on the basis of the 'unit doings' assembled in it. A further grade of assembly is the molecule. Its behaviour is intelligible in terms of the atomic systems assembled in it. Its behaviour is indeed statistically predictable. The molecule is itself a step toward a wider assembly of the units still. The assembling of certain atomic systems, particularly carbon, oxygen and nitrogen along with hydrogen, yield the molecules and through them the complexes which are, if we may use a word so out of fashion, protoplasm, living substance. This very commonly presents itself as an assembly, a further complex, large enough individually to be seen by the microscope, that is to say, huge as compared with the largest molecule. This complex assembly is the cell. It again is a unified system of doing, whose behaviour is intelligible in terms of the sub-systems composing it. Its organization is such that the character of its doing makes it, much more than is the ordinary molecule, a continually moving equilibrium. It is a field of dynamic interaction, and to maintain its running equilibrium it is in constant commerce with its surround, taking drafts from and paying drafts over to that surround.

There is yet another step upward in the scale of complexity of assemblage. That is where the cell itself, instead of remaining isolated, forms by coherence and special commerce with other cells a further assembly. That brings about the plant and animal of our ordinary experience. This further complex is in a sense additive and its doings as with the previous grades are radically resoluble into the doings of its sub-systems and ultimately into those of their sub-atomic units. Thus this song of 'the house that Jack built' is just carried a stave farther. But we do not forget that the complex aggregate composed of many cells arranges them together into a unitary organism. The organism is a case where the paradox obtains that the whole is much more than the sum of its parts. It is as we saw earlier, though an aggregate, an individual. It is its parts plus its organization. To insist on this is pretty much what Aristotle insisted on, under the term 'form', 'form' as a synthetic force, not a mere passive harmony of parts. This makes an impressive contribution to being.

The width of applicability of this concept 'energy' bears witness to its analytic depth. It unites all sensible structure and brings it into a form of doing. By it the atom, the rose we cultivate, and the dog our companion are alike describable. Within the descriptive competence of this unification comes our whole perceptible world, what it is and what it does. The sailing cloud, the bird below it, the setting sun, the coast and sea, the ship and harbour, the lighted window, the flock and the grass down, the voice of the shepherd, it unites these all into one consistent existence whose identical underlying nature becomes through it in so far intelligible to us. Their seemingly endless variety gains thus for man the interest of a concerted system, and, making the interest more poignant, himself is one with them.

The speculations of Democritus and Lucretius cannot be put beside this scheme. They were relatively to it essays in fancy, motived in their time perhaps chiefly as challenges to the Olympus of the day. The scheme arrived at now by Science is the fruit of patient toil, sifting out facts and in search of more facts, and exercising, it has been said, 'remorseless logic'. It has no tilt against religion as such. It knows its own field to be vast, but also knows it limited.

The anthropocentric outlook of mediaeval Christendom never welded its world into a unity so coherent as is this. True, the zodiac and man's body, the macrocosm and the microcosm, were for that age balanced together, the one as the counterpart of the other. The mediaeval orthodox scheme of things had its multiplicity of categories of things, its inanimate, its animate, its spirits, its innate heat, its sidereal essences, its astral fluid, its demons, its angels, its immaterial substance. Its categories though constructed with painful ingenuity were ill-defined. The mediaeval world did indeed succeed in unifying its manifold. But it went outside them to unify them. It unified them by appeal to theology; they were all the creation of the one Great Artificer. The energy-concept of today unifies its manifold in a way radically other than that. It unifies all the things of its manifold without going outside them.

Thus, a difficulty which, though starting much earlier, still haunted our representative of the sixteenth century, Fernel, was the association of 'form' and 'material'. It had exercised Aristotle. Today the single concept, the energy-concept, includes and relates both. Again, in the Middle Ages, and after them with Fernel, as with Aristotle before, there was the difficulty of the animate and the inanimate and the finding of the boundary between them. Today's scheme makes plain why that difficulty was, and dissolves it. There is no boundary.

We were reminding ourselves of the scientific table, a sort of electrical scaffolding, which though it is chiefly emptiness does all that the every-day table does. My elbow can lean on it as on the every-day table. My elbow itself is in the same case. Whether we call it a scientific elbow or an every-day one matters not, for the former describes exhaustively all that the latter is and does. Both the scientific and the every-day elbow are one and the same system of electrical charges. It is of no use, as we saw, asking physics and chemistry whether it is alive. They do not understand the word. That distinction between the elbow and the table falls as inessential. They agree that there are differences between them, and that the elbow can do a number of things which the table cannot. That on the other hand what the table does it will probably continue to do the longer. They agree that at some future not distant time, predictable with statistical reliability, the elbow will abruptly cease to do those things which the table cannot do. They tell us that when that time comes there will supervene for the moment no very striking immediate change in the elbow, no gross external change. The most immediate change will be that the streaming of oxygen at its present rate through it, stops. The rate of the molecular exchanges fall, and with that the energy-radiation attending them. This change rapidly becomes irreversible. There had been a certain running equilibrium involved in the upkeep of the elbow. Broken for even a brief time the equilibrium becomes irrecoverable. Then the whole as an organized system is doomed. It falls to ruin. It ceases to be an elbow. Its chains of enzymes are ungeared. It is a prey to myriads of parasitic enzyme-systems invading it from without. Instead of one co-ordinated system of energy, it becomes millions. No longer an elbow it is the scattered redistributed parts of a million other things, parasitic or not.

As the single unified system it specifically was, the elbow was a thing which the planet's side had not until recently seen, and it did things not until relatively recently done. As dissipated and distributed among a million other systems it is, although as a particular system annihilated, still existent as thus distributed and dispersed; it is moreover ready for endless permutations further. Sir Arthur mentioned what happened if the house caught fire and his table were burnt. It vanished in scientific smoke. The elbow, with its supra-tabular powers, if it did not escape burning with the burning house would disappear in much the same manner as the table. The difference between them was largely that their ultimate parts were differently arranged together; the burning reduces them both pretty nearly to ultimate parts with relatively little co-arrangement.

The elbow was an organization which took much longer to produce than, when made, whether burned or not, it lasts for. The history of its becoming before it was actually arrived at is in outline known. A conservative estimate would put its type as having been 100 million years on the road in making. But individually it does not at best endure much over three score years and ten. But the design, if we may so call it, once executed, the elbow goes on repeating itself to pattern or nearly so for a not inconsiderable time, it may be many thousands of years.

Of course in thus saying we remember it is but a sample of a completer organization we took it from. We might have taken some other sample from that organism. Some other organ. The heart, the brain. We could still have said much the same and have come to the same result. The brain would have resolved into the same ultimate electric charges similarly rushing about in what has been described as mostly emptiness. Electric charges organized into an ascending hierarchy of increasingly complex systems, atoms, orientated molecules, colloidal complexes, cell-fields, and cell-aggregates, such as we have sampled. An organization maintained for its time by oxygen-stream and blood-transport, as has already been said. In short a dynamic equilibrium which harmoniously dovetails in with a number of others, as just a part of what they likewise are parts of, the integrated body.

The energy-concept, we saw, embraces and unifies much. How then do all these latter, these organisms, these lives, these integrated lives to which the elbow is adjunct, stand in relation to that scheme? Are they all included, they and all they do?

The whole perceptible is included, therefore they are included. They and their 'doings' are movements and since motion is part of the perceptible or indeed constitutes the whole perceptible, their doings as well as themselves are included in the scheme. The scheme seems coterminous with the perceptible. Therein lies its immensity and also its limitation. Immense as it is, and self-satisfying as it is, and self-contained as it is, it yet seems but an introduction to something else.

For instance a star which we perceive. The energy-scheme deals with it, describes the passing of radiation thence into the eye, the little light-image of it formed at the bottom of the eye, the ensuing photo-chemical action in the retina, the trains of action-potentials travelling along the nerve to the brain, the further electrical disturbance in the brain, the action-potentials streaming thence to the muscles of eye-balls and of the pupil, the contraction of them sharpening the light-image and placing the best seeing part of the retina under it. The best 'seeing'? That is where the energy-scheme forsakes us. It tells us nothing of any 'seeing'. Everything but that. Of the physical happenings, yes. A tiny patch of a particular radiant energy disturbing the surface of the body in a region specially reactive to it; it connects that patch with an energy-path entering the eye, then with one carrying brainward from it, a shower of repetitive electric potentials. It locates these in a certain region of the brain, which it therefore indicates as concerned with what occurs in us through the eye. It also accounts to us for all the manœuvring of the eye-balls as they catch the photo-image and sharpen it and place the eye centrally under it, so too for our turning of the head to help the eyes.

But, as to our *seeing* the star it says nothing. That to our perception it is bright, has direction, has distance, that the image at the bottom of the eye-ball turns into a star overhead, a star moreover that does not move though we and our eyes as we move carry the image with us, and finally that it is the thing a star, endorsed by our cognition, about all this the energy-scheme has nothing to report. The energy-scheme deals with the star as one of the objects observable by us; as to the perceiving of it by the mind the scheme puts its finger to its lip and is silent. It may be said to bring us to the threshold of the act of perceiving, and there to bid us 'goodbye'. Its scheme seems to carry up to and through the very place and time which correlate with the mental experience, but to do so without one hint further. If the energy-scheme exhaust motion and embrace all 'doing' then the act of perceiving would seem not to be motion and, it would seem, is not 'doing'. Otherwise it would be included. So with the whole of mental experience, the energy-scheme leaves it aside and does not touch it. Our mental experience is not open to observation through any sense-organ. All that the energy-scheme submits *is* thus open. The perceptible and the energy-scheme are co-extensive, for both are for us rooted in sense. Our mental experience has no such channel of entrance to the mind. It is already of the mind, mental. We can turn no sense-organ upon it. Such expressions as 'internal sense' mislead if they are taken literally. The mental act of 'knowing' we are aware of, but we cannot sensually observe it. It is experienced, not observed. It is experienced whether we try to observe it or not. The attempt to turn observation upon it seems to fail somewhat as an attempt to do two things at one time can impair the doing of each. If the mind is pursuing a clue in a crossword puzzle, it is not assisted by trying to divert part of itself into an observer of that pursuit. "To endeavour to do two things at once is to do neither", was a dictum of old Syrus. The effort amounts to an attempt to get behind Nature's arrangement for us each to do one main thing at a time. It is an attempt at disintegration of the self. It were probably better to have recourse to memory, and to calling up the memorial traces of the mental act which it is desired to make the object of observation.

Another difficulty for analytic study of mind seems to arise somewhat as follows. Our mind passes on from one conscious act to another. It is always an activity in process. A new situation is commonly one in which there intrudes something besides what was antecedent. Thus, we are looking at an aeroplane when we hear a cry from the street. Into the consequent new situation the cry perceived, that is the cry as a mental event, enters as a factor in a new situation. It contains (it may be) emotional affect. Leaving that aside let us call it for the moment a 'percept'. As percept it is a complex of certain mental components, a something heard, with 'place' 'in the street', with time 'now', and as to kind or 'species' 'a human voice', it may be 'a child's voice'. Whence is all this? The physical sound in the ear was just a physical vibration. How did it generate this mental complex which seems suddenly to invade the mind full-fledged? It cannot have been born full-fledged. It must have gone through a becoming. That is, its activity has undergone some change, in which it would seem various factors were confluent. It has mental structure. How was it produced? Out of what was it constructed? Our experience does not say. It is as we experience it an already constructed complex. We have no awareness of it before then. Its beginnings are unreachable by our mind, though our mind is the only means which could reach them. There would seem therefore to be a grade or grades of mind which we do not experience, as well as the mind which is our mental experience.

We said above a percept. What is a 'percept's' becoming? We are probably agreed as to where it begins. It begins in sense. But from then onward the transformation is great.* It must involve much 'becoming' including intuitive unargued inference. Aristotle wrote of 'unconscious purpose', but here, it would seem, is unconscious inference. All this, it might be thought, would take long to arrive at accomplished ripeness. But no; a fraction of a tenth of a second suffices. The not-experienced in it must therefore precede quite closely what is experienced. The passage from the former to the latter would seem to be abrupt; it is at least rapid. Here therefore would seem to be a transit from

* For the reader interested in perception two recent outstanding works are Sir John Parsons' *Introduction to Perception* and Mr H. H. Price's *Perception*.

infra-mental to mental and it would seem to be quick. We found earlier that a quasi-material half-way house is not admissible; neither is a quasi-mental. Therefore here the pre-experiential stage is already mental although it is not experienced. To experience is to be aware of; the antecedent of the experienced is here the mental which we are not aware of. In so far it is a case like that other one, where "our hand has caught the fragile cup as it fell before our mind seemed fully aware of its falling, let alone could issue orders for saving it!" A mind which is not a part of experience seems at work. It may be objected that the mind is awareness, and if this is not awareness it is not mind. To answer "this is mental because the mind uses it", is not quite enough. To call it the subconscious seems to declare better its nearness to mind. We incline to suppose that all the mind is is 'thinking'. Is the mind 50 p.c. 'thinking'? Much of it lies outside 'thinking'. Yet but for that other 50 p.c. there would be no thinking.

There is some analogy between this and the disappearance of mind as traced downward in the animal scale. But in the latter the tracing is by perceptual observation and inference, in the former perceptual observation is from the nature of the case excluded. In the latter, the transition from recognizable mind to unrecognizable seems gradual. The mind which we experience, if we try to extend our experience into the process of its making, seems to become almost at once unable to be experienced. It eludes us by becoming subconscious. It is as though our mind were a pool of which the movements on the surface only are what we experience. In the situation we spoke of, the cry was a disturbance gaining entrance somewhere at the bottom of the mental pool. Travelling upwards through the pool it shapes itself and accretes to itself and grows, until reaching the surface it contributes in the form of a percept to the general disturbance obtaining there, and is experienced as part of the mental situation or action which for the time being is experienced. The mind which we experience, that is, which *is* our mental experience seems to emerge from elements of mind which we do not experience. Here we have not to do with the unconscious of Freud which is only temporarily unconscious, and has been conscious once and may be again. That belongs to a mind of a different grade, and a sphere of reaction other than that we are thinking of now. In our rough simile of the pool, the unconscious of Freud would be itself of the surface of the pool, but a piece of surface which lay as it were by a charm restrained for the time from entering activity, and therefore from participating in the general consciousness, a restraint which we might correlate with the inhibition which visits the nervous system far and wide.

The kind of fact which lets us suppose that the mind we experience is in part at least the outcome of mind which we never experience as such, is of a humbler order. Without looking at my arm I 'know where it is'. It might be thought that I derive this experience from touch, the touching of the arm against my sleeve, and so on. But no; I bare my arm entirely and I know where it is. In the swimming bath, without touch sensation, I know where it is. But when sensory nerves from the muscles and joints are destroyed, as may happen in disease, the patient will not know where his arm is, unless he looks at it. In bed he is apt to 'lose his arm'. The awareness of where the limb is, and what position it assumes is, if we direct attention to it as we experience it, a somewhat vague experience. With myself at least it seems accompanied by a dim visual phantom of the limb, especially perhaps of the hand. I have the impression that my mind, aware of the limb and its posture, then in its effort at attention to that experience conjures up a visual memory of what the limb looks like in that posture.

The main sensual basis of the awareness of the limb and its posture rests, as disease and experiments show, on the sensory nerves of the motor structures in the limb. Of such nerve-fibres there are many thousands, and they individually register the tension at thousands of points they sample in the muscles, tendons, and ligaments of the limb. These keep on firing into the nerve-centres nerve-impulses reporting, so to say, the tension of thousands of sample-points within the limb. In my awareness of the limb and its posture, and similarly in my awareness of its movement when it moves, I perceive no trace of all this. In 'experiencing' the limb I find no hint of this multiplex origin of the percept, no additive character in it, no tale of tensions within the limb, or of its possessing muscles or tendons. I am simply aware of where the limb is, and when it moves—

or is moved, for my moving it myself hardly helps my perception of it further. The percept is a not very vivid one.

I can in a way put to a pragmatic test the intimacy and exactness of my acquaintance through perception with this my limb. Since the perception comes not via eye or touch I may call it my motor-limb. If I use the limb to do this or that, say to pick up a paper from the table, the engaging the muscles rightly will have to reckon with the degree of tension and contraction in them already, for that is the starting point of the new action. On that depends how much more and other action has to be called up. But as I said I have no awareness of tension in the muscles: I have no awareness of the muscles as such at all. Yet I execute the movement rightly and without difficulty. It starts smoothly as though I had been aware precisely of how tense and how long each muscle and tendon was, and, thus aware, took them as my starting point for shortening or paying out as may be, each one further. If my sensory nerves from my muscles be destroyed as in some diseases they are, that right start of my movement is just what I cannot do. I start clumsily, with too much or too little. It does not in that respect help me much to look at my limb, though doing so does provide me with, in addition, the visual whereness of the limb. The important thing is my proprioceptive experience of where the limb is, experience which because it is provided by the limb itself is called 'proprioceptive'. What I experience as 'my arm', although not so vividly experienced as the perceived 'child's cry', is something homogeneous and entire. It bears no trace of being composed of a thousand and one sensory elements such as psycho-physiological analysis of the sensory apparatus of the limb would have me believe it must be. Mental constructive activity here, as in the case of the child's cry, seems to produce the mentally experienced out of mental ingredients not as such experienced. The proprioceptive percept of the limb seems a mental product derived from elements which are not experienced and yet are mental in the sense that the mind uses them in producing the percept. Such mental products are an intimate accompaniment of our motor acts. We may suppose therefore there obtains something like them in our animal kith and kin as accompaniment of their intentional motor acts.

If the subconscious, in our meaning of the term, play the rôle we recognize it to do in ourselves, we may well think that in older types of mind, from the like of which ours is a recent excursion, its rôle was a yet richer. What is called 'encephalization'* is an evolutionary change which is strikingly exemplified in ourselves. It is a shifting of function in the brain from older and more primitive to newer and more complex parts. Of these last the chief, newest, and most complex is the roof-brain, 'organ of mind' so called. There is good evidence that some of our old motor acts are being uplifted so to say from old and more primitive places in the brain into this newer 'thinking' part. The ingravescent dominance of this last seems modern. Our gaze has become more 'thinkingly' directed. Perhaps, could we share the mind of forms of life greatly other than our own, we should find no 'experience' anywhere in their life, but only subconscious mind. Subconscious mind can, it would seem, 'learn'. We know that of it in ourselves. Witness the types of motor 'skill' which it is our delight our out-door games should give us.

Strong contrast offers between the success which has attended analytic study of the perceptible and that which has attended analytic study of the percipient. The former has prospered the more. Man's analysis of his sensible world seems to have outstripped his analysis of his own mind. It may be said that to analyse the sensible world is in truth to analyse the mind. But asked whether that were what he was after in analysing the sensible world, man would surely reply, "No; my object was to understand better the world which I perceive." Having that intent he has in recent centuries prospered in his object. The scientific descriptions of the sensible world from of old, even from the intellectual hey-day of classical Greece, seem in observation and inference sadly superannuated to a reader of today. After a halt of many centuries, the study of the physical world strode forward. With the study of the mind it has been different. There, as regards analysis of the mind, the difference between classical Greece and now is by a modern reader felt to be far less. It may be argued that the analysis of mind as compared with that of analysis of the

* For concise account of this see Fulton's *Physiology of the Nervous System*, Oxford, 1938.

physical world was early relatively advanced. If so, it has, as compared with physical science, advanced but relatively slowly since. The fact remains that ways of thought regarding the mind would seem during the last 2000 and odd years not to have changed to anything like the extent which ways of thought about the perceptible world have changed. Since classical times physical science has taken the perceptible world and so described its doings as to make of their entirety a new world of thought. But progress of knowledge has not done anything like that where its object is mind. By contrast, still today we may ask have we any right with such a word as 'doing' in application to the mind. Reasons for this difference of success would seem not far to seek. An entity which where accessible to experience is not open to quantitative measure, and otherwise is not open to experience even at all, is an entity indeed refractory to analytic treatment. The method followed successfully in investigating the perceptible seems to provide no paradigm for the method to be followed in investigation of what even though experienced is literally the insensible.

The complaint is sometimes heard that "we have learned to control nature before we have learned to control ourselves". But to bring such a complaint against civilization is to forget that the two theses are not comparable. Their problems do not fall even within the same category. If we are pushed to assess the two comparatively we find the latter not only vastly different but vastly the more difficult of accomplishment.

Not for one moment would I seem to harbour the thought that the labours and results of psychology are not worthy of our admiration and attention. Probably never were psychological studies more vigorous than today. They have important work in hand. For one thing the formulation of certain recently deciphered 'laws' of thought (Spearman). Yet, we must feel that the mind has proved through recent centuries far less tractable to study than has the sensible world. For one thing conscious experience seems refractory to measurement in terms of itself. We cannot say that in experience one light has twice the brightness of another. The terms in which we measure experience of a sound are not terms of experience. They are terms of the stimulus, the physical sound, or of the nervous or other bodily action concomitant with the experience. Or the measurement may be in terms of some motor act, which is taken as an outcome of the mental experience. Mind, if it were energy, would be measurable quantitatively. For quantitative measurement of the mental we resort to the energy-scheme. But the validity of that resort is questionable. The search in that scheme for a scale of equivalence between energy and mental experience arrives at none. The two seem incommensurable.

Further, within the confines of even the simpler psychical, there are great obstacles to quantitative comparison of one species of psychical fact with another: thus, between quantitative estimation of the brightness experienced from a light and the loudness experienced from a sound, or between the experienced intensity of a touch or a taste. But, all these as physical stimuli are quantitatively measurable in common terms and are comparable with each other. The advantage for study is immense. 'Figurism' insisting on the psychical whole being more than the sum of its parts would be on safer ground if instead of *more* it say *other* than.

No attributes of 'energy' seem findable in the processes of mind. That absence hampers explanation of the tie between cerebral and mental. Where the brain correlates with mind, no microscopical, no physical, no chemical means detect any radical difference between it and other nerve which does not correlate with mind. In both regions, whether 'mental' brain and 'non-mental' brain, changing electrical potentials along with thermal and chemical actions make a physiological entity held together by energy-relations. To correlate with that physiological entity, a suite of mental experience, a complex of thought, feeling, conation, an activity no doubt, but with what if any relation to electrical potential, heat and chemistry. For myself, what little I know of the how of the one does not, speaking personally, even begin to help me toward the how of the other. The two for all I can do remain refractorily apart. They seem to me disparate; not mutually convertible; untranslatable the one into the other.

This time-worn difficulty meets our theme at more than one place. It stands, for instance, at the very threshold of sense. We saw how the sense-organs are perhaps better called 'receptors'.

They are specifically fitted to pick up, i.e. to 'receive', stimuli which by their means the body can react to. But they do not all of them or at all times by so doing affect 'sense'. The energy-mind problem asks "how can they affect sense?" Sense is an aspect of the mental; how then can the physical receptor affect sense? That the physical receptor, e.g. the eye, connects with the roof-brain does not remove the difficulty. How can a reaction in the brain condition a reaction in the mind? Yet what have we sense-organs for, if not for that? This difficulty with sense is the same difficulty, from the converse side, as besets the problem of the mind as influencing our motor acts.

I would submit that we have to accept the correlation, and to view it as interaction; body → mind. Macrocosm is a term with perhaps too mediaeval connotations for use here; replacing it by 'surround', then we get surround ⇄ body ⇄ mind. The sun's energy is part of the closed energy-cycle. What leverage can it have on mind? Yet through my retina and brain it seems able to act on my mind. The theoretically impossible happens. In fine, I assert that it does act on my mind. Conversely my thinking 'self' thinks that it can bend my arm. Physics tells me that my arm cannot be bent without disturbing the sun. Physics tells me that unless my mind is energy it cannot disturb the sun. My mind then does not bend my arm. Or, the theoretically impossible happens. Let me prefer to think the theoretically impossible does happen. Despite the theoretical I take it my mind *does* bend my arm, and that it disturbs the sun.

Organic evolution, with its ways and means, appears to the biologist to treat and handle body and mind together as one concrete individual. To a human spectator it may well appear that the long series of animal creation has its *raison d'être* as a mechanism *for* evolving mind. He inclines to regard his own mind as the precious product which was the desideratum. But in that he may be suffering from 'anthropism'. The human mind is not a goal. Nature has started the bird's brain after already putting potentially the human on its way, that is, has started another and inferior mind after reaching the ground-plan of the human mind. Be that as it may, he regards his mind as associated with his brain which is also a part of him. He sees his brain so placed that certain nerve-paths reaching inward from specialized bits of the body, the eye, the ear, and so on, bring physical events, as it were by some natural magic, into such relation with the mind that they affect it. In other words, as we said, the theoretically impossible happens.

At the core of this difficulty is the attribute 'unextended' as applied to the finite mind. It is difficult to reconcile this attribution with certain facts. The mind of the individual, finite mind, as judged by an impressive concensus of opinion, has 'place'. It has 'whereness'; nor does it matter for our purpose of the moment what 'where' it has. It has a 'where'. Speaking for myself, although I can allow dialectically a Euclidean point and admit its artificiality to be a helpful convention, it is beyond me to conceive or figure or imagine even approximately a concrete anything as having whereness without magnitude. A thing without extension as descriptive of the mind, even though negatively descriptive, fails for me to be more than a conventional symbol. Kant seems, I would think, to have had something of a not dissimilar difficulty, when he wrote* of the human soul that it "resides in a place of a smallness impossible to describe".

Accepting finite mind as having a 'where' and that 'where' within the brain, we find that the energy-system with which we correlate the mind has of course extension and parts and exhibits, moreover, marked spatial organization of those of its parts correlating in space and time with the finite mind. The roof-brain is a veritable labyrinth of spatial construction. With different parts of that labyrinth observational inference connects different mental actions. Thus, different ranges of memory are injured by brain-affections of different seat. There is a 'visual' part, an 'auditory' part, and so on. Again, in this 'mental' part of the brain 'touches' from different points of the skin are registered at separate brain-points, and each psychical 'touch' has according to its place its particular psychical 'local-sign'. Space relations of the brain seem then to count mentally. Different 'wheres' in the brain, in short, correlate with different mental actions. Nor is it that an 'unextended' mind simply

* *Sammtl. Werke*, ii, 332, Hartenstein, 1867.

jumps from one spot to another. Two or more different activities of mind correlating with different 'wheres' in the brain are commonly in action contemporaneously. It may be asked whether these separate regions are not mere separate channels of physiological approach to a mind-focus of Euclidean-point character. But their relation to mind is closer and more 'mental' than that. Witness such observations as those cited earlier from Dr Holmes. We have, I think, to accept that finite mind is in extended space.

Again, the change in living organisms which evolution produces is, as examination of them proves, a recollocation of the elemental parts. It is a rearrangement, a reshuffling, and often an addition of more such parts. The mind of the organism is embraced as well as the body by the evolutionary process. This would seem presumptive evidence that the mind has parts which can be reshuffled and amplified under evolution. But reshuffling, recollocation, implies extension in space. The mind to undergo it would seem to occupy extended space.

Again if 'things' through nerve can act on finite mind—and most of us would admit that to be the basis of perceiving—it then becomes difficult to suppose action between energy and mind is unilateral only, solely energy → mind. The action should be reaction. In that case mind influences energy. My mind seems to act on my 'material me' when at breakfast I lift my coffee cup with intent to drink. I infer a like situation in the chimpanzee when he peels his banana before eating it. Reversible interaction between the 'I' and the body seems to me an inference validly drawn from evidence.

The 'how' of it has the difficulty that finite mind is not an object of sense. There are at least two ways of being insensible, in other words, imperceptible. One way is to be quantitatively too little, i.e. below threshold. Another is to be inadequate to any sense-organ. Our sense-organs miss a number of the world's qualities and quantities of energy. Scientific devices help us partly out of this disability. Thus, nervous impulses in a fish's organ of smell may be insensible by our unaided sense-organs, but when Adrian to study them converts them into a noise like rattling rifle-fire, the roomful of us can hear them. By scientific means our powers of sense can in such ways be much extended. Yet the mental itself remains obstinately inaccessible to sense, and to all these extensions of it.

It may be so because it is not of the category of energy at all. Here we have of course to remember that in looking for mind as energy we are not looking for a form of energy then to translate it into mind. Of that we have abundant instances already. Thus, radiant energy *via* nerve into seeing, or into heat-sensation, or pain. That would be to look merely for forms of energy which nerve can transmute through sense into the mental. What we look for is an energy which *is* mind. In short we seek whether mind is energy; whether for instance seeing, feeling, pain, thinking, etc. are manifestations of energy—*are* energy. No evidence as yet assures us of this. No organism seems furnished with any sense-organ which takes into its purview even the place pertaining to its finite mind. We may perhaps take that as equivalent to saying that no advantage would accrue to the organism if its mind were an object of sense to itself and therefore it is not so.

One fact remains. Mind providing us with time and space, there is no mystery about one relation between energy and mind. Between the individual human mind and the individual human forebrain considered in time and space there is a 100 per cent correlation. Relying on that the surgeon rescues the suffering mind by relieving the brain from the tumour compressing it. Of this correspondence our knowledge becomes each decade more precise. Disease, wounds, cures, treatment, physicians, surgeons, all these various witnesses, dissentient on some questions, here agree. Is it indeed a question any longer? Practical life has long since decided that it is not.

Pragmatic judgement here, as often, ranges itself beside Nature's practice. Pragmatic judgement accepts ourselves as compounds of energy and mind. In the instance of ourselves and of numerous animal forms not very unlike us, evolution has dealt with them and us as compounded of 'energy' and 'psyche', and has treated in us each of those two components along with the other. The two components are respectively, on our analysis, an energy-system and a mental system conjoined into one bivalent individual. In the case of the energy-system of that bivalent individual our knowledge finds it a long continuum in time which for each individual is traceable back without interruption for a moment through at least some millions of years. The energy-system of any one of us is today's continuation of one traceably in operation since Ordovician times, not less than 20 million of years ago. The present individual is the latest bud from that perdurable energy-pattern which has without intermission been throwing off buds of its pattern for these last 20 million years or more. When death comes to any one of us it means in fact, unless he or she have progeny, the ending of the branch of a thread which has hitherto spun itself unhaltingly through those millions of years. That continuum is a material continuum. It is this continuum which evolution has through those years moulded into the present individual, making him a modification of individuals past.

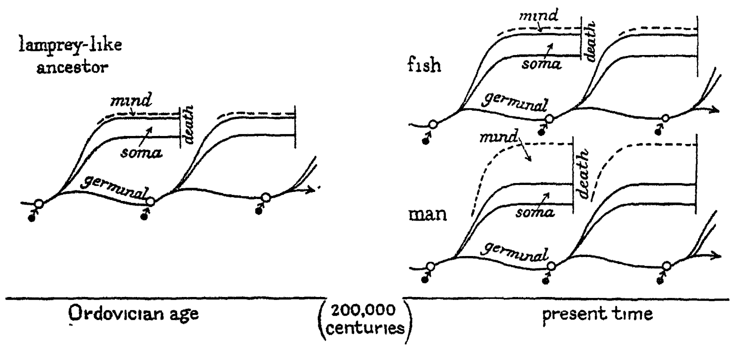
If we turn, however, to the other component of the individual, namely the psychical component, the fact is different. It too, our information tells us, traces back through the same ages and geological periods. But its long history has not been a continuous one. It has been a succession of brief discontinuities. At repetitive intervals along the continuous line of being which the sister system, the energy-system, maintained, the mind was wanting. At beginning of each successive generation of the energy-system the psyche lapsed, only to appear after that physical system had reached a certain stage. For a time in each generation the individual appears not to be bivalent at all; for it has no demonstrable mental component. In the *purely germinal* system of the individual there is never strict evidence of mind at all.

The bodily life which can be traced as a continuum back into the geological past is therefore not accompanied continuously by a mental life. There would seem no mental continuum. The bivalent individual although its successive generations as energy are continuous, is mental only in discontinuous phases.

The accompanying simple figure may here help. Mind seems to reappear *ex nihilo* at each repetition of the soma after the soma has reached a certain stage of ripeness.

How are we to account for this recurrent appearance of mind? Jean Fernel has explicitly told us how he explained it.

His explanation, though he did not know the circumstances nearly so fully as we do to-day, does strikingly meet them. It is, however, an explanation employing data which lie outside our scope. An explanation after a very different manner from his would be offered by supposing that the chemico-physical system of the soma, complex as it is and accounting as it does for so much of the 'living' behaviour of the individual, accounts also for his mental behaviour. That would be to say that finite mind is a product of the individual's energy-system. The mental would in fine be a form of energy.



Schema indicating continuity of successive generations as energy-system but discontinuity as mental system.

——— energy-system. – – – mental system.

Speaking for myself I experience no inherent aversion to such a view. It has for me a certain attraction because bringing life as a whole under one monistic rubric. The simple figure, indicating that when in the developing soma its integrated assembly of chemico-physical systems reaches a certain completeness and complexity mind appears, does seem to prompt an inference that the latter is a result of the former. But against that rises the difficulty that mental phenomena on examination do not seem amenable to understanding under physics and chemistry. I have therefore to think of the brain as an organ of liaison between energy and mind, but not as a converter of energy into mind or vice versa.

We have, it seems to me, to admit that energy and mind are phenomena of two categories. In that case the phasic appearance of a mental system alongside the energy-system of the developing body has the difficulty that the mental seems to spring suddenly out of nothing. But we have already dealt with instances in ourselves where mind is clearly inferable although not directly recognizable by us. If that be so in ourselves, still greater is the difficulty of observing mind objectively, that is as object, when, by its very nature, it is insensible, i.e. not accessible to 'sense'. Mind as attaching to any unicellular life would seem to me to be unrecognizable to observation; but I would not feel that permits me to affirm it is not there. Indeed, I would think, that since mind appears in the developing soma that amounts to showing that it is potential in the ovum (and sperm) from which the soma sprang.

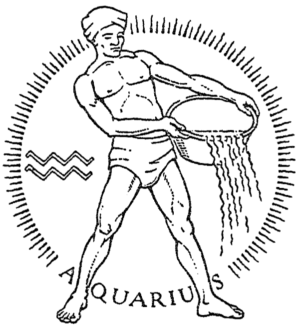
The appearance of recognizable mind in the soma would then be not a creation *de novo* but a development of mind from unrecognizable into recognizable. It is at this point therefore that on these admissions we become committed to dualism. But while accepting this duality we remember that Nature in instance after instance dealing with this duality treats it as a unity. Evolution evolves it as one. In this body-mind individual, with its two cohering systems, bodily and mental, even as the former component exhibits both inherited and acquired features, so too does the latter. The latter's acquired traits, even as those of the body, are not demonstrably transmitted to the succeeding generation. Thus, with the domestic dog the habits it acquires under our training we have to re-teach to its offspring; they do not reappear by inheritance. Domestication, however, with its training enters as an element into the domestic dog's 'surround'. It, therefore, like other elements in the surround, can exert selective pressure. Our domestic dog is therefore not today born just as much a stone-age puppy as if domestication had never been. A hundred thousand years of domestication may well have left him genetically more disposed to domestication. There is in him something of an inherited disposition toward the social. And so too I would suppose with ourselves in regard to civilization.

Nature has evolved us as compounds of energy and mind. The scene of this operation has been the planet where we are. I would submit with deference that for one of like gift to the historian, here is a theme whose telling would be welcome to humanity. A theme which I would still think of as historical although much of it run back beyond tradition. Even if as fact it be too cloudy for history, it is yet worth telling as an available truth: the planet's story with what it has made and done. No item of the universe is self-contained, but the planet is an item more self-contained than as yet any history has taken for its theme. Because more self-contained it could yield a fuller and more satisfying account of what we as part of it, telling its story, are, and of whence we are and of perhaps our whither. Such a story would give a range in time more adequate to our problem. History has set down much concerning the last 5000 years. But a past which counts in millions of years can supply broader criteria as to what is to be. Is 5000 years a perspective long enough to disclose reliably a general trend? The natural trend of our past to forecast our future by it is that for which many yearn to have knowledge.

If, as is sometimes said, history is the tracing of past purposes, here is a history which might, while telling of past purpose, whisper to us of future purpose. It would seem so to whisper to us, to whisper that we have been Earth's purpose. We must not let that flatter us too far. It adds 'not as an end but as a means to a further end'. Moreover our reflexion adds that history read backwards will whisper that same answer to each of its products which shall make that enquiry of it. Not that that makes the answer untrue.

Our debt is great to the historian. He has dispensed much to us. Histories of kings, of cities, of countries, of this political movement and that, of philosophies, and of the chequered records of peoples and their leaders. Sometimes he has taken a whole continent's story of civilization. History grows. It reaches beyond written tradition. Pre-history becomes history. Palaeontology unfolds to us like a chaptered tale the shapes and powers and ways of lives which went before our own. Geology sets forth for him who will read the record of the rocks; astronomy tells of the becoming of the stars. But there is yet this other theme at once comprehensive and intimate. The history of our planet, all that it comprises and has done and made. It asks to be written, and so that all may read our planet's becoming which contains our own. It asks to be undertaken, after the same manner as was undertaken not so many centuries back the myth of the nine-fold heavens and of man's life at their fixed centre, set forth so that all pious Christendom could hear. So begs to be set forth this story of our planet in its newer light to be a frame to set our lives against and within. It is a story not remote for us because it is our own. The planet in travail with its children. With the Universe as heroic background for what to us is an intimate and an heroic epic. A birth in cataclysm. Aeons of seething and momentous shaping. A triple scum of rock and tide and vapour—the planet's side—swept on through day and night. Then from that side arising shape after shape, past fancy. And latterly among them some imbued with sense and thought. And still more latterly, some with thought eager for 'values'. The planet, furnace of molten rocks and metals, now yielding thoughts and 'values'! Magic furnace. Beside its alchemy and transmutations the most impassioned dreams of Hermes Trismegistus and all his fellowship dwindle to paltry nothing.

Man in his mood may count himself in his day a brief spectator of his own shaping as it still progresses; so too of the planet's fertility, in commerce with its surroundings, even as he, the spectator, born from and attached to it. The commerce of both is with the sun and beyond that with what to the spectator has often seemed the illimitable, so far as the illimitable is thinkable by him. The human spectator has in mind that in this spectacle the planet is an offspring of the sun, and that he the spectator is in turn an offspring of the planet. He has in mind that all earth's tenantry, his fellow-tenantry, are as autochthonous as he. Earth's offspring, comprising rock and soil and sea and cloud and plant and brute and himself, man. In all that tenantry, he is among the latest come. The planet with its offspring, to him, its latest child looking around him, becomes something of a community. It counts for him as a something which although an aggregate of many parts is yet for him embraceable and intelligible as a unity. It is more to him than merely his setting and the home which houses him. It, with what it comprises, shapes before him to the likeness of a familial assembly, a community of related things. Of things which are parts of one greater thing. He sees the whole an organization, not static but progressive. Remembering life as a grade of organization he sees progressive organization in the planet include life and promise more life. At one time it had not that organization which means life. He envisages energy as the vehicle for mind, progressing under progressive organization of those types of system which unfold life. The whole presents itself as one great graduated scale of surging organization. He reflects that at one time the planet can have had none of his particular variety of system. Now it has. That is, it has evolved recognizable mind. This has issued from its side, at the interface where atmosphere and other physical phases meet, under alternate day and night. The planet has thus latterly become a place of thinking. More, it now harbours mind which values 'values'. It is a planet now with hopes and fears and tentative 'right' and 'wrong'. A planet which is human. What will be to follow? Our pragmatic spectator watching his mother-earth believes that there will come forth from her side more mind, and still more mind. The further evolution of energy-systems will he thinks accomplish that. Perhaps for that they strive. In believing this, he is not doubtful of touch between energy and mind.



XI

TWO WAYS OF ONE MIND

Our loves so truly parallel though infinite can never meet.

A. MARVELL.

Why then should we separate mental activity and cerebral activity seeing that the two are identical?

C. S. MYERS, *In the Realm of Mind.*

XI

LATTERLY our theme touched more than once the question of the relation between the two concepts 'energy' and 'mind'. I would venture here to turn specifically to that relation. To leave its argument, as that appears to me, merely tacit, might seem to invite mystery in a matter on which I would wish to arrive at clear expression. But over and above that there is an importance proper to the question. It has theoretical importance; that is perhaps generally admitted. But its claim to practical importance is apt to raise a smile. Yet the question surely touches the reading of man's situation in his world.

We need not think of it as an issue between idealism and materialism. Nor does it touch so-called 'reality'; our world is in any case an act of mind. It asks rather whether the world, as our mind apprehends it, is for one part of it known to us in one way, for its other part known to us in another, the two ways not of essential parity. One form in which the question states itself is how far the world as known to us is fundamentally of one kind throughout. We may then regard the question as that of dualism or monism in a limited scope, that is, with no reference to reality. To me what ultimate reality may be is one of those questions which rise to the mind, and that the mind of itself has not the means to answer.

We saw ground for thinking that in the evolution of mind a starting point for 'recognizable' mind, lay in its connection with motor acts. Motor behaviour would seem the cradle of recognizable mind. I incline to endorse the challenging remark, that, "the most fundamental function of mind is to guide bodily movement so as to change our relation to objects about us".* Moreover the motor act is that which seems to clinch the distinction between self and not-self. The doer's doings affirm the self. Lotze's trodden worm contrasting itself with the world found of the two its trodden self the greater. We may wonder at such anthropoid reflection on the part of the worm,

* W. McDougall, *Outline of Psychology*, p. 235, London, 1923.

but we grant the statement expresses fairly the view native to the 'self'. The worm shares the impulse as motion though not as thought. And surely even as early as the 'suffering self' arose the 'doing self'. As far back in the evolutionary tree as intuitions go among them must be that of a subjective 'doing'.

The concept 'self' taken with all its connotations has become vastly far-reaching and intricate. Yet it would seem to have at its core an element relatively simple, germane to our question here. The awareness or consciousness of each of us, prominent in certain of our motor acts, relates the self to the act. The awareness is of course an example of what in the abstract is spoken of as mind. It seems a law of mind to connect its phenomena by relations. The awareness attaching to these motor acts relates the conscious 'self' to the acts as doing them.

In our awareness when doing these acts there would seem awareness both of the self and of its act, and a connection between them. This awareness-complex comes traceably from two sources. One source is sensual. The motor act in its bodily execution consists of changes in several bodily parts, for instance, changes of length and tension in muscles, etc. The muscles besides being motor instruments are sense-organs. The muscular act therefore affects sense. There is perception of the act. Sensual perception has, as always, spatial reference. Its awareness carries reference to the bodily parts operating the act, for instance to a limb, a finger, or what not. It is an awareness which, as the phrase goes, 'projects' spatial reference, in this case into the moving limb, finger or what not concerned in the act.

But there is in the conscious motor act an awareness also of the 'I-doing'. This latter awareness is not derived from sense. It is the 'I's' direct awareness of itself acting. A difference between it and the awareness derived from sense is that while that which derives from sense has, as we said, spatial projection, this which is not derived from sense has no spatial projection. It is awareness of the self 'doing' but it is not projected.

Projection is a term helpful in dealing descriptively with sensual space. Perceptual space might be written here instead of sensual space, except that it is wished here to stress its derivation from sense. The vexed question of the mode of origin or genesis of sensual space we have not to enter on. We accept the brute fact that our mind's perception through the senses immerses us in 'space'. To see a thing is to see it somewhere. And so with all the other senses. That may seem nothing to wonder at, but to reflection it is perennially astonishing. We can only observe it, leaving it a 'final inexplicability'. Observation shows our sensual space is a closely unified space, although the several senses make to it separate contributions. Sensual space is always just '3-dimensional' space, Euclidean space; Euclidean space is 3-dimensional perhaps because just sensual. Projection applies to what is sometimes called its third dimension. The total of sensual space for our percipient self at any moment may be likened to a sphere with the percipient self set central in it. Projection applies to the radial distance from that percipient self. Awareness, which is the self, identifies together as one 'self' the successive various phases of itself, the I-perceiving, the I-doing a motor act, the I-feeling, etc. Whichever self it is it is central in sensual space.

Sensual space, although to pass centralward along any radius in it is finally to come to the 'I', is never actually so explored. The exploration always stops short before coming to the 'I'. Nevertheless projection is thought of as radial distance from the central 'I'. The whole of the perceptible of sensual space is found to be 'projected' because sense as regards actual experience always lies outside the unprojected central core where the 'I' is.

If we think of projection in grades, the perceived star is farther than the perceived toe, the toe than is the perceived tooth. The 'I' is even more central than is the perceived tooth and its pain. In no direction of sensual space is the 'I' projected. Yet its centrality is somewhat vague. Perhaps we can put it best by saying that it is always more central than is what it perceives.

In the complex of awareness belonging to a conscious motor act there is, along with the awareness of the 'I-doing' which is unprojected, the sense-derived awareness of the bodily act which is projected, for instance, referred to the moving limb. This latter is by spatial projection separated from the unprojected 'I'. The bodily movement is therefore distinguished from the 'I'. The mind, finding relations between phenomena, seeks also to couple some phenomena as cause and effect. This bent or tendency has served it well. Whatever it may mean, it has helped to sift events conjoined by sequence in time. The mind relates the 'I-doing' in the conscious motor act causally with the act. The unprojected 'I' is the 'cause' and the projected motor act is the 'effect'.

In this attribution we need not suppose that any conscious logical argument is at work. Rather it would be a naïve unargued assumption. One of those unanalysable workings of the mind which are practically tantamount to inference but are drawn unconsciously and often so quickly that the conclusion is reached before there would seem time for full comprehension of the data. It is a mental analogue of the physiological reflex. There seems an integration of 'primary' processes underlying sense comparable with and on a level with the integration of raw nervous processes. There seems a whole field, or many fields, of such unconscious mind. Unconscious mind in a meaning, as we said, quite other than the Freudian. The subconscious unargued inferences which convert *sensa* into symbols out of which the perceptual is built. The reflex avoidance of danger even before the situation is intellectually appreciated. Unconscious phases of mind producing conscious handling of situations with conscious results. To such a class of mental action, we may think, have to be traced the beginnings of the relating of the primordial 'self' to the motor act as 'cause' of the act.

This 'relating' is a momentous example of the 'causation' habit of our mind. This 'I' which when I move my hand I experience as 'I-doing', how do I perceive it? I do not perceive it. If perception means awareness through sense I do not perceive the 'I'. My awareness and myself are one. I experience it. The 'I-doing' is my awareness of myself in the motor act. It is my mental experience in that phase of my activity. It is, if we prefer, my experience of 'self' explicit in action. In it my 'self' is not an object which I can examine through sense. As compared with the latter I am at the disadvantage that I cannot submit this to others besides myself to examine and report on. It is private to myself, but each of us can examine his own case. For examining it, all we can do is to attend to what we are aware of in it.

This may be felt too trustful of introspection. If introspection be our impressions of our own consciousness those impressions, although perforce individual, may yet be representative. However we have to be on our guard. The term introspection can, as is often insisted, be misleading. It might suppose that we can turn some perceptual process upon the 'I' and watch it and treat it as an object of perception, so to examine and analyse it. Kant was one of those who continued late to use the term 'inner sense', although he does not always make clear with what meaning. The physiology of sense has advanced greatly since his time. The 'I' can never come into the plane of objects of sensual perception. It *is* 'awareness'. Even if the mind had a sense-organ which were turned inward, so to say upon the mind itself, what would it fulfil? Broadly taken, and briefly, and crudely put, if the purpose of sense be to translate events physical and chemical into mental, what use would it serve in application to the mind which is already mental? Besides the 'I', since it is awareness, would still remain not 'sensed'. The mind is no part of the perceptible.

But the mind does experience itself. Memory attaches to that experience. The self can remember and re-live at second-hand and reflect upon its experience of itself. It can think over what its experience in 'doing' was. That perhaps is more effective than the divided effort of trying to examine the awareness actually while the awareness is in process.

Of two components which can be traced in the awareness of a conscious motor act, one, we saw, is the immediate awareness belonging to the 'I-doing', the other the sensual awareness accompanying the bodily act. The second is in some instances, by disease or injury, stripped away. The dual complex of the conscious act is to that extent analysed. This happens when a limb though its motor power is retained is robbed of all sensation. The patient then does not sense his limb. He does not know where his limb is, unless he sees it. In bed he may 'lose' his arm. But the motor act is still evoked and consciously although there is no sensual perception of the limb. The 'I' still experiences itself in acting. The residual awareness in this insentient condition of the limb is therefore in so far not sensually given. It is the 'I's' direct awareness of itself in action.

It is true the motor act executed by the insentient limb is clumsy. That it is executed at all and consciously 'at will' is here the point. The launching of it as a conscious act although the sensory basis for it, and the sensual perception of it, are wanting, indicates that this 'I-acting' is not derived from sense-perception but is directly given.

That the execution of the act should be defective when the limb itself is insentient is as would be expected. For one thing, the injury which robs the limb of sensation robs it also of the proprioceptive reflexes which continually, even during sleep, regulate its tensions and positions. Certain of its muscles are slacker than they should be, certain are tighter. With the limb in that condition, we may liken the skilled act which the 'I-acting' is aware of launching, to the effort of a musician to play a melody on an instrument which is hopelessly out of tune. Some acts are still well executed after complete loss of sensation by the acting limb—thus the grooming of the skin in the scratch-reflex; but this latter movement although complex does not need, nor indeed reach, great precision.

The reading of mind from animal behaviour is often equivocal. But the behaviour of the ape with arms insentient seems to carry its meaning interpretably enough to be evidence in point. The animal, accustomed before the insensitization of the arms to climb a rope or the cage side for offered fruit, on seeing the fruit comes forward and raises the insentient arms to climb. But the uplifted arms miss their object, partly or wholly; they may not even make contact with the rope or cage-side at all. They wave almost wildly above the head, and, even at best, little progress or none is made in the ascent. The limbs are too clumsy. But they refuse defeat. The unsuccessful act is repeated again and again. For the attentive observer conviction grows that whatever a willed act is, a willed act is being enacted and by an individual acutely conscious of his own 'willing', and acutely aware that the bodily act as it comes to pass fails of being the act which the 'I-willing' set out to compass. The creature's looking at the limb seems to avail little or nothing. The situation can be read as a dramatic picture of the 'I' acutely aware of itself in a motor act. But it is the 'I' deprived of sensual perception of its tool, the limb, though still acutely active in 'doing' with the tool could it but handle it fitly. The 'I-doing' and the act it *would* do, seem still vividly identified together. It is the executive fulfilment of the act which fails. The mental reaction to this failure may be one almost of consternation.

The situation resembles that, depicted by William James, of the child deaf from destruction of the internal ear, finding itself spatially disorientated if under water in the swimming bath. It can be likened also to the patient unable to direct his eyes in a desired direction, let him try as he may. We remember Dr Gordon Holmes' description as a witness of this effort and of its distress.* Clearly in these situations the self-awareness is intense and is enhanced by the emotion engendered by the failure.

This 'I', this self, which can so vividly propose to 'do', what attributes as regards 'doing' does it appear to itself to have? It counts itself as a 'cause'. Do we not each think of our 'I' as a 'cause' within our body? 'Within' inasmuch as it is at the core of the spatial world, which our perception seems to look out at from our body. The body seems a zone immediately about that central core. This 'I' belongs more immediately to our awareness than does even the spatial world about us, for it is directly experienced. It *is* the 'self'. Yet never has it been seen, or felt, or although it has language has it been heard. It believes it is in daily commerce with many of like kind with itself but never have they any more than itself been seen or felt or heard by it or by any of themselves. Invisible, intangible, imperceptible, it is inaccessible to sense, although to itself directly known.

Even if it be in the body it is clearly no part of the body. It contrasts with the body. It has peculiar and important ties with the body. Of these the spatial concern us here. The body is spatial. For the 'I' the body is a sense-perceived object, whose parts are in projected space. They form a coherent object with a continuous contour extending on all sides round the 'I'. This contour has the 'self' within it. It carries the 'I', that is 'self', about with it. It is never absent from normal waking life. It is a zone of the perceptible around the 'I', a zone which resents encroachment upon itself by any other spatial object. It is for the 'I' in its way something sacred. If its field be invaded by any other object, such invasion is only at the cost of great disturbance to the 'self', a disturbance which the self calls 'pain', bodily pain. The 'I' intuits a special relation between this body and itself. It signifies this by applying to the body

* *Vide supra*, chap. VII, p. 226.

the terms 'me' and 'mine'. The 'I' in short is aware of itself as an *embodied* 'I'.

Thus, we may say, around the 'I' or 'self' is 'its' spatial body, the 'I' itself not sharing spatial projection with that body. Furthermore, it, the 'I', has no contour, no shape, no size. It has no spatial extent. In all this it is the body's antithesis. The hand, as sample of the body, has three-dimensional extension. It has colour, warmth, smoothness, softness, hardness, weight, etc. Of such attributes the 'I' has none. Does any awareness except that given by perception, i.e. based on sense, possess the attribute of space? Seemingly not. The 'I' in all its forms is inaccessible to sense. It lacks therefore a basis for spatial attributes.

Yet it seems to have 'whereness'. As to this 'whereness', the self's awareness of 'its' perceived hand says of the hand in regard to place that it is 'there'. So similarly of all else sensually perceived. Stone, tree, cloud, star, each of them is 'there'; a different there in each case, yet each of them a 'there'. But 'self' is never 'there'. It is 'here'. If pressed where 'here' is, what will it say? 'In the body?' Were we to demur; were we to expostulate with it and say "you are not spatial; how can you have place?" I think it might retort slyly, "have not philosophers complained for me that I am prisoned in the body!" We are left a little wondering whether it has not spatial reference after all, although a spatial reference not on a par with that of the body. The question can be illustrated from two writers each of whom had certainly given the question thought. One of them, Descartes, wrote in the *De Homine* after describing the animal body as a machine, "of a truth, I should say, were God to add to this machine [man] a reasoning soul, the place he would give it would be the brain!" We may infer from this that the spatial scene he gave to his famous 'Cogito ergo sum' was cerebral. But he puts the event there by abstract argument, without appeal to experience let alone to experiment; and is content to leave it a surmise.

Somewhat different is the treatment accorded by a second authority, Kant. He says of the soul that it has its seat in the brain; it sits there he says like a spider at the centre of its web. From that seat it puts into movement the ropes and levers of the whole machine. It produces at pleasure 'voluntary movements'. The body is an artificial machine in which the coming together of the nerves is condition for the faculties of thinking and willing—which seems an echo from Aristotle or the Theaetetus.

What is common to the treatment of the question by both writers is, we may feel, the remoteness of the answer. Descartes' remark, although he was after all 'interactionist', is almost a gesture of dismissal of the question. Kant's, although not that, had been prefaced by the remark, "If I am asked where the seat of the soul is in the body, I begin to suspect something crooked in the question." While allotting the soul broadly to the brain, he goes on that its smallness is impossible to assess. He makes it, in short, a Euclidean point, a position without dimensions. Much as Descartes made the 'thinking I' the antithesis of 'res extensa', so Kant refers to it as a something determinable in time only. There comes to my recollection an answer given by an authority of international recognition on the brain. He had shown us with his microscope the cells in a tumour of the brain. To the question whether any thinking would be done by them, he replied, "This tumour is only of the supporting cells, not of the true cerebral cells." The true cells evidently would think—not perhaps in a tumour because imperfectly organized there. Today's opinion therefore is in this less removed from Aristotle than from Kant. Our interest here, however, is the confirmation from the two philosophers of the want of spatial connotation attaching to the 'I', except as to a certain 'whereness', which sets it within the somewhat indirectly sense-given space-system of the brain.

We, I fancy, shall all agree that the awareness which is the 'I' or 'self' has its different dominant phases. Sometimes it is dominantly the 'I-doing', sometimes dominantly the 'I-feeling', sometimes dominantly the 'I-perceiving' and so on. In all these situations, perhaps especially the last, the 'I' finds itself surrounded by sensual space, but that space never actually attaches to it or gives it extension. Sensual space never gets grip of the 'I'. It does not reach the 'I'.

Sense treats of the body and of an external world outside the body. As might be expected, since these are both sensually dealt with largely by the same set of senses, the 'I' perceives them as parts of one and the same spatial system. In short the two are but separate items of the same spatial world. There are, however, differences between the two. The external world unlike the body harbours no 'pains'; unlike the body it is not one thing only, but multitudes of things. It is a time-space-frame populated with 'things'. Many of these things are perceptible through several senses. What distinguishes them all one from another perhaps specially is contour. Visual contour dominates visual space. Perceptually a contour is a line. When we hear that Nature has no such thing as a line, vision answers that all contours are lines. That every contact of fields of light or colour is sharpened and stressed into a line—a psychological line. 'Contrast' develops a 'line' at every contact between abruptly distinguishable areas. If the mind did not deal in 'lines' an outline drawing could hardly be the magical thing it can be. Simple outline diagrams, serving to illustrate 'figurism', can be rich in 'meanings'; that could hardly be unless the mind dealt in 'lines'? The so-called rivalry of contours is a master key to 'meaning' in visual perception. As far as the mind thinks spatially its thinking largely accepts 'lines' and manufactures them.

Space-perception makes of the external world and our body one continuous spatial scheme. For the 'I-perceiving' to think rightly, that is to act effectively, in regard to that space, it must appreciate how that space lies in regard to the 'I'. In other words implicit in its motor behaviour is a recognized relation between the whereness of itself and the extensity of the sensible world. Thus, visually, the self in order to react duly with its spatial world has to correlate itself with the viewpoint whence itself looks upon that world. For instance, on that foundation does it direct and manage its eye-balls properly. The 'self' must, in figurative phrase, know fairly precisely the 'where' of the viewpoint whence it looks at the world. The phrase is figurative because again we have an instance, though not in Freud's sense, of the unconscious mind. When we look out binocularly as commonly we do 'into' visual space, the 'I' predicates not two eyes but one. It unconsciously supposes it is looking out through a single eye, a cyclopean eye, which it takes to be low down in the mid-vertical of the forehead. Its perceptual interpretation of visual space assumes this 'point of outlook' to be at a subjective point which corresponds with a point in the nasal bone. At this point would lie the centre of rotation of the assumed cyclopean eye. The visual space-signature, to be understood, tacitly assumes that is so. The *visual* 'self' has thus a place assigned to it. A place which is a subjective point, a place which though it does fall within the body—in the head—does not lie within the brain at all. And it is a position, not a magnitude.

It might be interesting to know how far this *locus* given for the mental 'eye' agrees or not with, for instance, that given proprioceptively for a perceiving 'self' reaching out with the arm in various directions. There would be only working agreement between the two. Moreover the whereness of the viewpoint of visual perception changes, as the rifleman knows, when for taking aim he excludes the 'other' eye.

Is there truly any consciousness of the 'self' attaching to this viewpoint? There is surely no explicit awareness of self. The locus is arrived at as though by extending the geometrical construction corresponding with the spatial field of projection inward into the eye. In doing that it enters that core of the projection-sphere which visual sense can never directly include within its own spatial field. Therefore truly ocular though it be it is not truly sensual. It has no spatial extension, no spatial dimensions. As a locus it can be determined geometrically. But it has never been directly sensed. The wonder is that what we can perhaps best accept as unconscious mind should act as though this geometrical point were a datum for it, much as though it knew the geometrical scheme.

When therefore the 'self' is aware of a thrush on the lawn as 'there' with implicit relation to the self's own self as 'here', besides the difference that the former is projected the latter not, there are large other spatial differences between the two. The former has spatial extension, contour, magnitude, colour, audibility, etc.—the latter none of these. The former is further a cluster of spatial associations, e.g. that, were I to take it up ever so gently I should feel something ticking far faster than a seconds' clock inside a feathery warm handful. But the latter, this 'self' within me has no such associations visible, tangible, or sensible. As to space it is an unwittingly inferred 'position' only.

The contrast between the 'I's' apprehension of itself and its apprehension of the 'external world' is in a way wider than its contrast with its own body. The variety of the external world is the greater. There are sizes and shapes and brightnesses and colours, and hardnesses and softnesses and so on which give a range of diversity and extent strikingly contrasted with the many limitations of the body. For the 'I' this contrast shapes itself in part as a difference of relation which on the one hand the external world and on the other the body, bear to itself, the 'I'. The body is claimed by the 'I' as 'my' body; the external world is not claimed in that way by the 'I' as 'mine'. Unlike the body which as one and the same body is never absent from the 'I's' experience, the things of the external world go and come and are met and parted from.

The 'self' is aware of self not only as 'here' but as 'now'. The 'I' endures in time. Just as space is a continuum for it, so also is time, but time is a continuum which moves. Time passes. Much as in the old cosmology the Sun moved and Earth did not, so customarily temporal change is charged by us not to ourselves but to 'flow' of Time. And though we think of flowing Time as a continuum, much as in space-continuum we conjure up lines, so in our time-continuum we distinguish brief stationary cross-sections of the flow and speak of each such as 'now'. That such a 'now' is an artefact does not prevent it from serving to integrate the 'I'. The mental items embraced by any 'now' compose one integral whole, which is the 'self' of the moment. Mental contemporaneity, apart from any necessary cerebral conjunction in space, combines them. The 'now' is a pragmatic 'now', sometimes longer, sometimes shorter. Conation, an attribute of the 'I', deals with a 'now' which has yet to be; and memory, another attribute of the 'I', recalls a 'now' that was. There are therefore future 'nows' and past 'nows'. The 'I' when followed along time has different phases, but it does not question its being one and the same 'I'. It is the same 'I' but in different 'nows' and 'heres'. It remains self-identical in spite of changes.

In regard to the two indefinables, 'space' and 'time', the 'I' in each of them is central. It finds itself always central in a world of 'things', itself an existence without contour, shape, or dimensions, invisible, intangible, devoid of sensible attributes, lasting, although not long-lasting as compared with many 'things'. Compared with things it is largely a negation of all which goes to make things up, yet it is not the less a mental existence even as they. It is based on observation as truly as are they. It is as 'real' as they; perhaps more real than they. It seems the source of a concept in which spatial extension has no part. Things on the other hand come under a concept among whose contents spatial extension is. The two were distinguished by Descartes as on the one hand, matter in extended space (*res extensa*) and, on the other hand, 'thinking mind', by contrast with the former not extended in space.

The one concept is just as much based on factual observation as is the other. Strictly, the observation and fact underlying the non-sensual concept and its 'I' are, we may think, more at first hand and more unimpugnable than are those underlying the spatial concept and its 'things'. These latter are after all an inference. If either as fact is more unquestionable than the other it should be the unextended 'I', being the more immediately established. It has it is true one disability as regards evidence, it is impenetrably private. A spatial fact on the other hand can be attested by perhaps millions at first hand. The two therefore possess as testimony values of a different order. The fact which is as to first-hand provenance an experience private to its one and only observer, i.e. the self, is to others than that one observer merely 'report'. It is not strictly verifiable by a second person. Hence doubtless there attaches to its class of fact a certain mystery from which the perceptual, observable by many observers in common at first hand, is ordinarily free.

The 'I' which thinks itself within the body, regarding the body as having in it 'life', identifies that 'life' with itself. It *is* the life. The actions of the body are *its* actions.

We saw how in our friend Fernel's treatise belonging to its sixteenth century, the notion obtained of a spirit-like something in the body, a something which was the mind and the life-principle united, and was called the soul. It served as a point of accretion to many suppositions for whose factual rightness there was no natural touchstone.

For example, the spirit-like something came to be regarded

PLATE VII. SCOURGING OF THE APOSTLES

as an existence apart from the body. The body could not 'live' without it, but it could live without the body. It could enter and leave the body, could assume for itself visible shape. The craftsmen of old time would depict it as a flame, an aura.* It could migrate from earth to heaven and conversely, it could appear to a sleeper, it transcended natural laws, and so on. Its imperceptibility—though Fernel sometimes forwent that—provided it with a certain immunity from critical examination. The possible and impossible in regard to it were by that very circumstance more difficult to assess. The attribute of immortality was given it at cost of obvious inconsequence. To attribute to it immortality while at the same time identifying it with the sum total of activity of a body in itself notoriously mortal, involved certain contradictions.

The introduction of immortality into the concept of the life-soul proved in several ways a fateful amplification of the psyche. For one thing it ruptured that unity, the individual, the finite 'persona', which the psyche had contributed toward establishing. The individual becomes double. Parts which had been harmonious become in themselves separable and rival wholes. It is a sophistication without natural basis. St Augustine, great master of introspection and eager student of the soul, asking of himself "dost thou feel thyself simple or multiple", answered, "I know not".

An immense superstructure reared itself upon 'immortality' as an attribute of the finite psyche. There arose the whole of a possible economy for the presumed after-life succeeding death; a place for the 'after-life'; a system of rewards and punishments meted out in that 'after-life'. The very import of actual life itself was undermined by a postulated 'after-life'. Life shrank to a mere probation-period for 'after-life'. These adjuncts to the soul-concept, persisting for millennia in story and in faith, played their rôle in history. They influenced civilization. They have, as subject for reflection, not rarely been set forth in language of supreme felicity. Among creations of imagination some of these outpourings stand unsurpassed. For Fernel this inclusion of immortality among the attributes of the psyche was

* Fig. from *Rosario della gloriosa Vergine Maria*, Venice, G. Variso, 1561, p. 176 verso.

both a tenet of his religious belief and a fact of his science. With him and such as he such faith was no vice of egotism or crude bias of repugnance to cessation. It was with him a conviction which gave just one reason the more for taking life and himself seriously and devotedly. That was perhaps a designed motive for the original assumption. Fernel would, with his sympathetic nature, feel too that it affords a compassionate boon to those who dread the cutting of life's thread as the breaking of all human ties.

And expansion of the 'I' concept went afield in other directions. The 'I' is prone to read the like of itself into what it observes in the perceptible world. It pieces together phenomena by noting relations between them. Where the 'I' can, it interrelates by 'causes', that is its wont. A perceived phenomenon *a* is 'cause' of a perceived phenomenon *b*, and so on. But sometimes no perceptible cause appears. A branch stirs; the 'cause' is the wind. But the wind; what is the cause of the moving wind? The naively observing 'I' has in its own 'self' a prototype of invisible causation of movement. Its invisible 'self' is 'cause' of the body's movements. On analogy it can allot to the wind a like intrinsic and invisible 'cause' of motion. The wind becomes the 'motor act' of an unseen being, a spirit. Metaphor completes the 'explanation'. The wind becomes personified; Boreas, Zephyr, etc.—a primitive instance of a derivation from the 'I-doing' carried over into the perceptual world, there to explain the doings of that world.

I would not that my compression of statement here suggest these projections by the 'I' to be fully argued efforts on its part. Rather we must think them impulses of primitive imagination. Doubtless they answered practical needs as well. Caliban-like questionings were raised and countered Caliban-like. That would be at their beginning. Fancy's image of its own infelt something which it knew as 'I', was carried over in rough replica into a world of space, and in that world was assumed to be identified with things as 'lives' or 'souls' which acted in those things. The sensible world was peopled with such replicas. And always these replicas are regarded as 'causes'. A stone falls. The cause? An invisible power pulls or thrusts it down, a 'force' in analogical likeness to that prototypical invisible 'force', the psyche of the body.

An argument in the *Dialogue* illustrates this. When his pupil Philiatros asks Eudoxus what precisely is to be understood by a 'faculty' of life in the body, Eudoxus (Fernel) answers,* "If Lucas can sing and paint and play the lute it is he who is the cause of these acts, and he is so because he has the faculties for them. Now although a faculty can do nothing of itself, we say commonly that the lutist plays, the painter paints, the singer sings, though truly the body, the immediate cause of these effects, is neither lutist, nor singer, nor painter, but Lucas is. So the soul is the cause of the living function, and does all, but by means of faculties." Fernel is identifying 'Lucas', in analogy with the self, with the integral life-principle which resides in and works Lucas's body. Thus, the 'self' is taken to be in fact the 'principle of life'. The conscious individual is identified with the life. The actions of the body are *its*, the self's, actions. They are intelligible to it only as due to the immanence in the body of itself. Their immediate cause is itself. This view it has grown up with and may never have questioned or even put to itself as questionable. Some of these acts are especially its own. It can do them 'when it likes'. It calls them 'willed' acts. They demonstrate itself to itself as a power to do and as the 'cause' within its body.

But, mind proves refractory to description by physics and chemistry. It belongs to the unable-to-be-sensed, the insensible, where physical and chemical have no place. On the other hand the individual life consists of the physical and chemical, deals with space and is dealt with by sense. It can go on in absence of finite mind. To attempt to bring 'life' under the 'I' notion is for that notion to lay claim to attributes which cannot be shown for it. For the 'I' to claim the body's 'life' is therefore for it to embark on the undemonstrable and unprovable. Yet the treatise on physiology of 400 hundred years ago, does so. It works the body by spiritual faculties and sub-faculties for this and that bodily. process. The development of the young from the egg is a progressive change from shape to shape. Fernel handles this theme; his reflections upon it conclude that there must co-operate in it two processes, one stripping the material of the form already possessed by it, and one imposing

* *Dialog.* ii, 5.

on it a new and different form. Therefore* he calls in two spiritual sub-faculties of the great main faculty of growth (*procreatrix*), one the *immutatrix*, the other the *conformatrix*, and by their means the growth-faculty brings about the development of the young creature. Further, since in that development the growth of cartilage, for instance, is different from that of nerve, a number of separate species of these two sub-faculties have to be invoked. They all of them are immaterial forces, analogous in so far to the immaterial life-principle he posits as residing in, and working, the body. His belief is, in short, that living bodies, including his own, are worked to the last detail by intrinsic hierarchical systems of an immaterial nature. This is, in truth, the concept of the 'self' transgressing experience and invading the field of energetics as a 'cause'. But that is for it to enter on an adventure alien to its scope because alien to its nature. And the 'I' concept, during the conquering march of finite mind through the human millennia, often lent itself to trespasses beyond its proper sphere.

Assuming itself the cause of its body's actions it conceives itself as what Mr Monsarrat calls 'an ability to do'. It classes itself among powers which do. This is part of its natural history. We may attempt, as natural history, very briefly, some further description of its ecology and ways. We have taken it as part of the phenomena of Nature, and we would glance at its habits and ways within the natural scene. It distinguishes in the perceptible world a whole category of things which, on a like principle to itself, 'live'. To each of these it attributes a principle which is akin in nature and in ways and doings to what it imagines itself to be and do. We have seen how identifying itself with the acts of the body as a principle which does them it assumes itself to be a 'causal' principle of life. It does not stop at that. On the analogy of lord and slave it judges itself the lord of its body which, if things go rightly, is its slave.† Plunged in self-contemplation and remembering its powers to do, it proceeds to argue that this lord of its body is no earthly thing. It reaches the conviction that itself is a spark of the divine.

Although the body after a certain duration breaks up and as

* *Physiol.* v, 3, 98. † *Phaedo.*

a body disappears, the 'I' proceeds to suppose that it the 'I' will still continue despite the dissolution of the body. It has supposed itself 'living'; it then proceeds to suppose that it will not 'die', that it is 'immortal'. The 'self-concept' thus becomes a 'soul-concept'.

We have to remember in regard to the 'I's' notion of the scope of its own field and powers that the very lack of sensible attributes attaching to the concept of the 'I' deprives the exercise of fancy of some seasonable guidance and control. The 'sensible' is as we know a commonplace for the 'reasonable'.

The very 'principle of Nature' which we meet with in Fernel, * is an example. He says of it "no one has ever seen it, it is not demonstrable to sense, but we all know it, we know it from its effects. It is the producer [e.g. it brings together 'matter' and 'form'], the creator under God, of all natural things and events, and from them it is evident to reason." In short, the 'I' here is expanded into a 'principle' which stands for the principle of causation in nature, and in so far 'personifies' that causation.

The 'I-concept' thus enters the world of things under the guise of 'forces' with attributes of the 'I'. Even such a mind as Hobbes' speaks of weight as *conatus ad centrum terrae*.† Such 'forces' obey 'laws'. Hence the 'reign of law' in Nature. 'Force' when employed in physics hardly escapes some connotation of the 'I'. It is reminiscent of the Nature which once abhorred a vacuum. But, in its turn, the other, the rival, the sensual concept 'matter', has had its revenge, that is has been as guilty. It has declared the mind, insensible and thus imperceptible though that be, a 'waxen tablet', a 'flowing stream', a 'box', and more recently, as we saw, a 'machine'.

Part of the natural history of the 'I' is therefore its inclination to anthropomorphize the physical world. This habit appears in metaphors. The 'self' though never accessible to sense, when projected as a 'power' or 'cause' into the sensible world, tends to clothe itself in form, although no form is native to it. Its traits even when they assume godhead seek 3-dimensional shape. Ancient mythology instances this. Its deities are clothed in shapes. They enter the perceptual world though foreign to that

* *Dialog.* 1, 1. † *Element. Philos.* chap. VIII, art. 7.

world. Some of them were hybrids of form, almost incredible. Some of them were blends of beauty. Their vogue endured long, century after century. With forms often impossibly compact from different specimens of concrete Nature, went powers comparably praeter-natural. Fernel in his sixteenth century in the *Dialogue* rehearses the names and grades of some of these, both good and evil. For him in his century, although he set his face against natural magic and astrology, certain shapes and powers when vouched for by traditional authorities which he recognized, were real existences. They went to 'explain' the course of events and happenings of the perceptible world. Much later than Fernel, Kepler, astronomer and astrologer, 'explained' the ambit of each planet by the guidance of its angel-spirit. So it was the spirit-concept ran loose amid the world of things. The nineteenth century did something to reverse this. It was then that Emerson said, "things are in the saddle and ride mankind."

We saw that the behaviour of the body was regarded as manifestation of a life-soul within it, and that with this life-soul the 'I' was identified. The two as one and the same 'cause' explained and carried the meaning of the individual. Facing the external world and envisaging the sum total of that world and the behaviour of the manifold there, the 'I' assumed in explanation of that world a Cause, not dissimilar in type to its own self, the 'I'. This replica of itself was a greatly glorified sublimation of the 'I' but it was still in likeness of the 'I' as estimated by itself. The 'Cause' was therefore an image which although fashioned after human kind was exempt from a number of our limitations. It was conceived as a Being with quasi-human and supra-human characters. Its acts were like the doings of the 'I' on a grander scale. It felt emotions resembling those of the 'I', it recognized 'values' resembling those entertained by the 'I'; and so on. It personified, anthropomorphically, Goodness and Might. The primitive acceptations of this argument became elaborated into systems of faith. The strength of appeal they drew from presentation of the Being as a 'personal Being', serves to document their provenance from a transfigured 'I'. As to the evil which the 'I' recognizing 'values' encountered in the world, that aspect of its world-scheme was 'explained' by positing again a superhuman 'I', this time a wicked superman, or Devil. In the sixteenth century seen through the contemporary eyes of Jean Fernel and others this personal Fiend interfered sufficiently numerously with the routine course of Nature to be part of Nature's normal economy. Plato's Cacodaimon was licensed to work evil even within the régime of the 'world-soul'.

The naive 'I' observing that things, for instance 'its' body, appear to begin and end, sought also as to the external world how that world began and was to end. It took recourse to the all-powerful and all-knowing 'Cause' it had assumed, and found there its answer. It attributed the original creation of itself and of all the world to this same all-powerful and all-knowing Cause. It recognized itself as having some likeness to the Cause. Of that its interpretation was that the Cause had created it, the 'I', after Its own image.

Thus the 'I's' idea of itself as an invisible and intangible cause within the body developed and radiated. It took the form of a life-soul operating and controlling the 'life' of the body. It assumed the rôle of an immortal principle separable from the body. By imagination and use of analogy and metaphor it generated 'existences' and 'powers' somewhat after the likeness of what it thought itself to be and reduplicated these about the world. By these was operated to its satisfaction the phenomenal world. It accounted for the universe by means of a Cause imagined after its own type. We need not, for our purpose, follow further this apotheosis. In this ultimate expansion of its scope, the non-sensual concept comes to present an interest for the contemplative 'I' which exceeds that of the whole spatial world itself. We cannot wonder there have been the recluse, the saint, and the wrapt philosopher who have within these aspects of that concept immersed their lives.

But in these excursions of the 'I'-concept into exotic fields it came in some ways into collision with the other of the two concepts we set out to discuss. That other concept which we called the spatial concept embraces the sensible world and 'things'. This spatial concept based on sense has, as we saw, had success in its analysis of the world within its scope. It finds that, applied to that world, it can describe all that world in terms of movement. 'Things' then become in so far explicable as arrangements of what it calls 'energy'. It employs the two indefinables, space and time, and treating them metrically with minimal assumptions sets out to describe the whole sensible universe, and finds that it can do so. It resolves the things of its world ultimately into what for our purpose may perhaps be called 'units of motion'. The phenomena of its world it finds ultimately describable as electrical. We bear in mind that these units of Natural Science are devised for the purpose of describing the phenomena. Science does not, I think, regard electrons, protons, neutrons, etc. otherwise than as mental figments, symbols. It has not supposed them 'ultimate reality'. A point for us here, however, is that they are symbols in the service of the spatial concept, not of the non-sensual. The description they supply largely satisfies man in dealing with the phenomena of the perceptible.

But this description which it has accomplished is found to render in many respects the accounts offered by the non-sensual concept, the 'soul-concept', in explanation of the same phenomena, unnecessary. The non-sensual concept, when it got amid the world of 'things', entered the field proper to the spatial concept and there dealt with spatial things although incommensurable with them. It supplied explanations of them and 'causes' of their doings. Foreign amid these things and doings, for it was thus a non-sensual concept in a spatial milieu, and recognizing its surroundings as in so far alien to it, the non-sensual concept rated its own status as superior to that of the 'natural' world. That world was phenomenal, whereas itself was 'spiritual'. In its endeavours to account for the happenings in that phenomenal world the soul-concept supplied the phenomena with 'causes' of the 'deus ex machina' type, fashioned in likeness to itself. The result arrived at was that the spiritual operated the 'natural' world. The 'I's' explanations for what was difficult to it in the 'natural' world were taken from the behaviour of itself, on a non-sensual plane therefore; a plane it considered above the plane of the 'natural'. Over the natural was, as came to be said, the 'super-natural'.

As analysis of the natural world by the spatial concept, which we may call the energy-concept, went forward, the explanations of that world by the other, the 'spiritual' concept, were challenged by those which the spatial concept itself could submit. And in this field reason, when it has before it alternative explanations of phenomena, one by application of the non-sensual concept, the other by application of the spatial concept, prefers the latter. For instance, in regard to life. Thus our philosopher-physician, Fernel, four hundred years ago, carried over, as was the wont of his time, the non-sensual concept in the form of 'faculties' and 'spiritus', into the human body to do there what he saw the body did, and so to explain these doings and what was called the 'life' of the body. But with the gradual development, since then, of the sensual concept and its application, those processes of the body one after one have found their explanation in the time-space behaviour of the proper substance of the body. Their scheme conforms with the 'energy' scheme in general. The body has in so far proved to be an energy-system; then and in so far it does without unextended 'faculties' and 'spiritus'.

Thus, breathing and the rhythmic taking in and giving out of breath has, from a mystic visitation by a life-giving spirit from the heavenly sphere, become an affair of gas-pressure, transport of a pigment, and the play of enzymes. These are all spatial. The sentient soul, 'anima sensitiva', which dispensed motor powers in the body and had at its behest 'spiritus' as means to that, has become a physical polarized network over which little leaks of electrical potential travel, and reinforce and interfere. The growing of a pin's-head speck into a child, bearing individual likeness to its parents, a tour-de-force of the natural world for which Fernel demanded the co-operation of an occult ray from beyond the Sun, has come under the rubric of the spatial concept; it is an affair, even to its patterned design, of chemistry and physics, nor does that make its interest the less absorbing.

The application of the non-sensual concept has therefore been curtailed in scope. The key positions which it had occupied as ruler of the body it has relinquished. Life, as a principle by which the body lives, has been taken from it. Life as such is found to belong to the other, the energy-concept. With the falling of the stone and the falling of the star, bodily life is counted in the tale of things which energy describes.

Strange to relate, these two sister and complemental concepts have in the course of history been the war cries of conflicting parties. The two concepts were, so to say, flown as hostile banners. There was rivalry between them, rivalry for the possession of 'life' and of the 'world'. Not, to be sure, rivalry between the concepts themselves; they are complemental and necessary one to the other. But bitter rivalry and enmity, even to persecution and death, between the partisans of the two concepts.

The ousting of 'life' from the list of powers which the non-spatial, the soul-concept includes, was not welcome to the partisans of that concept. For life to be merged in the ordinary currency of 'energy' under the other concept came to many as a bitterly unwelcome disillusion.

The non-sensual concept essayed to exploit, as we saw, the external world. Much in the same way as it peopled the body with ghostly faculties, so too it peopled the outside world with spirits, and genii, 'powers' and 'forces' operating things and their doings, especially as 'causes'. Gradually its sister concept, the sensual concept, found that these happenings in and between 'things' could be described in terms of the things themselves. The intrusion of non-spatial powers pertaining to the other concept became a trespass against the law of parsimony. The spatial concept could deal with 'things' and their behaviour adequately on its basis of 'energy', without intervention from the other concept. The explanations offered by the non-sensual concept in terms of its own kind, were found to provide a merely *ad hoc* facility rather than any penetrative statement of relation. The spatial concept gradually on the basis of 'experiment' extended its application in the world of things and their doings. At first it did so piecemeal, and later, as the separate pieces touched and fitted together like a jig-saw puzzle, wholesale. Finally the whole spatial world, examined by the spatial concept, assumed the appearance of a scene in which 'energy' described it all, all which was and all which had been. The motif 'cause' then lapsed. It helped no longer. It was an excess.

In course of time, therefore, the progress of thought, and of positive knowledge, has dealt austerely with the two concepts.

No field of experience is now open to which hybrid conceptions, partly or temporarily spatial and partly or temporarily non-spatial, apply. Now it must be one thing or the other, space or no space. Intermediate fields had once been generally admitted. There had been go-betweens, in which non-sensual and the spatial properties combined or alternated; spiritual substances which were at once material and immaterial. The astral fluid of the astrologers was such. The 'spirits', vegetative, vital, and animal, of old-time Medicine were such. Socrates' 'familiar' was such. The demons of medieval Christendom and the incubi of the post-renaissance witch-hunters were such. In Fernel the word 'substantial' as opposed to 'corporeal' was of that service. This removal of the intermediate was in effect a purification of the two complemental concepts in their own respective applications. They had been allowed to mingle. They do so no longer. This perhaps is mainly owing to the advance in descriptive power of the spatial concept using its space-time figment 'energy'.

This in its turn has had further repercussions on the position of the non-sensual concept. The ambit of its excursions has been curtailed. The field to which it aspired was vast. Recent times have taken from it some of its ambitions. It claimed to operate Nature; it claimed to include 'life', an immortal soul, existences which directed whole reaches of the physical world, and a Cause which maintained, controlled, and had indeed created the universe. Some of these claims were set forth by their supporters with a passion and devotion never in literature excelled. Yet time teaches that a number of the claims themselves have in cold truth to be regarded as extravagant.

I have been trying to outline as an item of Nature-study the growth and extension, and then the restriction and purification of the applications of this non-sensual concept. When it has been stripped of untenable pretensions, what remains to it? There remains then a residue inalienably its own. A residue more precious than any of its mistaken ambitions. A residue valuable beyond expression, for language, its own half-perfected instrument of expression, is not adequate to express it to the full. A residue which is the source of all of its splendid 'realities' as well as of all its dreams. A residue which contains *all* the 'values'—for space is irrelevant to 'values'. In a word the conscious 'I', called in the abstract 'mind'. And what a residue! Among its contents are those two same concepts we have been following, creations of thought, embracing between them more than the Universe, for if we call the Universe energy, they embrace mind as well. It may be said this residue, beyond all problematical 'reality', *is* the 'value' of our world.

We have to note then that the result to which we are led in so far, is not a direct endorsement of natural theology so called. The mind by its own unaided vision looking at our world does not find that world resolve into a First Cause and the things which That has created and maintains. It finds, so far as I can exercise 'its' vision, that our world resolves itself into energy and mind.

These two concepts, and they are two concepts of one mind, divide, and between them comprise, our world. One of them, the spatial, which we may call the energy-concept, derives by way of the senses. The other, as we saw, is not derived by way of any sense. We saw why. The mind has no sense which it can turn inwards so to say upon itself. The idea which mind forms of itself lacks extension in space, because sense is required for such extension as a datum, and mind does not derive its idea of itself through sense. Mind as an object belongs to the insensible. When mind is the object of its own experience, it, unlike the objects of sense, lacks spatial extension. That, one may think, may depend not on the phenomenon observed but on the mode of observation. Suppose it be said, my mind may be spatial, and yet if it be within my head, I shall not see it or sense it because, as agreed, I have no sense-organ within whose field it can come. It may be something spatial and sensible although not accessible by sense to me. The difficulty, however, lies deeper. If the mind, hidden so to say from access of all the senses, be supposed sensible, in order to be sensible, since observation shows all which sense senses is energy of some kind, it should be some kind of energy. But nothing known of mind brings mind within what we conceive as energy. Mind refuses to be energy, just as it has always refused to be matter. And energy on its side refuses to open its ring of aspects to admit mind among them. All energy's aspects are compact of motion, and therefore predicate extension. Extension is what is denied to mind.

The old formal difficulty rises, how can mind envisage itself? If it is conscious how can it *not* envisage itself? Yet the two modes of approach may well have different results. If we can imagine the mirror contemplating itself and its world, it might well say of itself "around me is a 3-dimensional world, but I myself am 2-dimensional; I am a surface only; all my ways belong to 'Flatland'; I am, however, immersed in a world which has depth". It might divide the world of its experience into two categories, this 2-dimensional, that 3-dimensional, somewhat after the paradigm of our two categories spatial and unextended. A difficulty for it would be, how could the phenomena of the two interact. If the mirror tried to forecast its own adventures outside Flatland on an excursion into that world around, it might assess itself to be impotent there, but, inasmuch as it perceives it, pragmatically it combines them.

Similarly with our two concepts, space-time energy and non-space mind, how can the phenomena of the two interact? Do they interact? The more the biologist studies life the less I fancy does it seem to him like life to have a loose wheel spinning. Yet how shall a spatial wheel cog into unextended mechanism or the non-spatial drive a spatial wheel? Spinoza, thinking of Descartes' interaction between the rational soul and the pineal gland, wrote, "I would fain be told how many degrees of movement the mind can give to this little pineal gland, and with what force it can lift it. I feel surprise that so great a man and philosopher, one who has laid it down as his rule to draw conclusions only such as are self-evident, and to assert nothing of which he has not a clear and distinct perception, he who so often has reproached scholasticism with explaining the obscure by qualities which are occult, allows himself an hypothesis more occult than all the occult qualities put together." Actually the dilemma is now become for many acuter still, if that be possible. The pseudo-'go-betweens' have vanished. Not that they in truth, I think, ever existed for either Spinoza or Descartes; the latter likened the animal spirits to fine fire, i.e. they were physical.

'Energy' proves itself a closed system, shutting out 'mind'. They may be juxtaposed, but they do not blend. An instance where perhaps particularly they approximate is at the mental process and the cerebral process. There on one side electrical potentials with thermal and chemical action, compose a physiological entity held together by energy-relations; on the other a suite of mental experience, an activity no doubt; but in what, if any, relation to energy! A suggestion has been made that we must re-define 'energy' so as to bring 'mind' into it. We have not in our power to re-fashion a concept shaped by our sense-perception. Again, it has been ingeniously said that had in the development of Science biology preceded physical science, a concept reached by Science would have embraced 'mind' and 'energy' together, merging them without disparity. But who shall jockey 'space' out of its natural rights?

The puzzle might seem not altogether unlike that in regard to the physical interpretation of light, and indeed of 'matter' generally. The electron, following its discovery, acquired charge, mass, spin and a special dynamics of its own. But that was not enough to carry the observational data which accrued. Matter, like light, was found to possess both the properties of particles and the properties of waves. Louis de Broglie put forward an equation expressing the correlation of the particle-behaviour and the wave-behaviour of matter. This budded into a synthesis. It achieved success in accounting for, and even to the extent of predicting, many observed facts. But its basal assumption that a particle is associated with a system of waves is, I imagine, accepted as an assumption and left unaccounted for.

So our two concepts, space-time energy sensible, and insensible unextended mind, stand as in some way coupled together, but theory has nothing to submit as to how they can be so. Practical life assumes that they are so and on that assumption meets situation after situation; yet has no answer for the basal dilemma of how the two cohere. There is no more of course than mere analogy between this mind-energy complex which teases biology and that other the wave-particle dilemma which has been teasing physics. In the latter case both of its terms are at least assimilable in the measure that each is describable by space into time. Both are in short physical. The biological dilemma is of another order. In it the two terms are divergent to the degree that while the one is sensible the other is insensible. How then account for conjunction between two incommensurables? The physical dilemma however treated as parable does offer a certain pragmatic counsel. To carry on in biology as if the two terms, mind and energy, whose connection we cannot describe, are conjoined and to do so for the reason that to observation they act connectedly. With all humility, I imagine that physics argues "wave and particle seem, although we do not know how they can do so, to go together as one. We accept that without understanding it." Newton's essential modernity showed itself in no way more than in his acceptance of what he declared he could not account for. Our parable would preach acceptance of energy and mind as a working biological unity although we cannot describe the how of that unity.

Practical life regards, for instance, our thoughts as answerable for what we say. It proceeds as though qualities of mind, e.g. memory, courage, rightness of inference, and so on, affect the acts we do. Law proceeds on the same assumption, in its corrective system as elsewhere. Parent and schoolmaster regard well-bestowed praise as promotive of well-doing. Society in general regards mind as productive of acts. While our conception of the mind as unextended seems to preclude mind from interacting with any energy-system, the body inclusive, every-day life assumes there is interaction and that our mind shapes our conduct. Here ethics surely takes the same view as does daily life.

Of this dilemma Nature herself, if we may so apostrophize her, takes no notice. She proceeds as if no such dilemma existed. Nothing is clearer than that in her process of Evolution she evolves in living creatures characters which, largely as they spell advantage or disadvantage to the individual life, tend to survive or disappear. We have seen life *per se* to be a system of energy. Since life is a system of energy a character to be of advantage or disadvantage to that system must influence that system. Nothing is clearer than that mind has evolved. Mind therefore has had survival value. Mind it would seem then has an influence which Nature finds can count for advantage to the energy-system colligate with it, the body. Mind, as we know it, is never any other than embodied mind. Hence such properties as size, shape, movement, etc. are assessed by mind as being of account. Nature in her process Evolution, although we do not know her as ethical, proceeds as if believing in a working relation between mind and body as does our human ethics.

If the 'I-doing', which stands at some disadvantage, as we saw, for observing itself, had, instead of assuming that it was the 'cause' of its motor act, regarded itself simply as colligate with the act, a part with it of one event, the seeming inconsistency between the two concepts in this situation would disappear. There would then be no need to ask for interaction. Then, that Nature deals with both as one explains itself. The evolution of the one is of necessity the evolution of the other. There is no causal relation between them; they are both inseparably one. Their correlation is unity. The 'I' can accept itself as one aspect of the act. The 'I-perceiving' is not then a 'cause' within the spatial world. The 'I-experiencing' is just a part of the act it experiences. The relation is not as cause and effect but as parts of one event. So the relation between the 'I-doing' and what is done is not 'cause' and 'effect', but two colligate and concurrent components of one event. The 'I-doing' becomes thus in effect another aspect of its motor act. Its motor act and it are one. Its motor act can be called rightly a 'conscious motor act'. That is exactly what it is. Its awareness is part of it. It can also rightly be called a willed act, unless by that it is intended to say 'will' causes the motor act. This cannot be phrased more adequately I think than by some words in the *De Anima*, although their context is somewhat different from the present. "We must add that to speak of the soul as feeling angry is no more appropriate than to speak of the soul as weaving or building. Perhaps, in fact, it is better to say not that the soul pities or learns or infers, but rather that the man does so through his soul." * The motor act and the 'I-doing' appear as two parts of one event, one fitting the spatial concept (energy), the other the non-sensual concept (mind). This is akin to regarding the finite mind as a sort of esoteric activity bound up with the cerebral activity, an inner phase of which the

* E. Wallace's translation, i, c. 4, § 12, p. 41, Cambridge, 1882.

nervous activity is the outward phase. A phase which we can never reach for examination as we can the outer phase; an intrinsic activity of which the only evidence is conscious experience, and often not even that, so that then nothing.

Still there would be strange discrepancies to admit. The mind would then be an inward life, complement of an outward life; but existent only in nerve and only in a particular nerve-field. And there is the difficulty that the outward process on analysis proves always to be 'granular', quantal, 'structured'; the inner process to be structureless, non-quantal. The side of more direct approach is that of the non-sensual concept, for it escapes the 'way-round' through sense. But this latter approach with its 'way-round' provides a view which is at once different and in a manner the more complete, having its two indefinables 'space' and 'time' instead of one only. By the direct approach no relation of the observed to the general space-time continuum is given, hence no quantitative description or statement in the ordinary sense is possible. Meaning by science 'natural science', no scientific knowledge is obtainable by the direct route.

On these considerations 'energy' and 'mind' although incommensurable become two complemental concurrent parts of one serial event. That is not to say at all that mind is an aspect of energy or energy an aspect of mind. Our concept of energy affirms it as something complete in itself. A self-contained cycle which has no crevice for interpenetration by anything else, let alone mind. Similarly our concept mind excludes energy, for the nature of its own content is non-sensual.

The finite mind, wherever we can recognize it, is embodied mind. That is, always it is colligate with energy. Judging from what we can trace of the development of recognizable mind, the organization of that mind seems to go with the organization of the energy-system which is its body. It develops especially along with the development of certain types of energy-system. We saw that what is called 'life', which natural science regards as not distinct from the rest of energy-behaviour, is a sum total of behaviour characteristic of changes and 'steady states' of certain complex energy-systems. A form of progressive organization which this type of energy-system and its behaviour exhibit is integration. That is with increasing complexity, there is nevertheless, increasing unity. The system is so organized and integrated that in upshot there results a totalitarian behaviour doing just one main act at a time. That one main act is what in the total of the 'life' of the system its recognizable mind especially accompanies. Its mind seems then to be integrated even as in the energy-system, its body. This integration of the mind gives it, in the estimation of itself, the semblance of a unity. Recognizable mind then is one aspect of this organization even as that form of energy-behaviour which is called 'life' is another. It is therefore not surprising that the process of evolution when bringing about further organization of the 'living' energy-system develops along with the integrated body the integrated mind. The mind and body are two series of events concomitant in time as parts of a single series.

The whole of a concrete 'life' (if we abstract from it the mental where that occurs) the spatial concept embraces completely. It is an assembly of energy-systems which is saved by integration from being merely additive. Our sixteenth-century Jean Fernel's 'life-principle' we cannot find. If we understand by 'things' concrete instances of delimitable space-time systems, then 'things' present a class called 'organisms'. It is a class which cannot, however, be satisfactorily shown to differ fundamentally from the rest of 'things' except where, as in a number of instances, an organism has the mental demonstrably pertaining to it. We have difficulty in assigning the lower limit of the mental. It may therefore be that its distribution extends to all organisms, and even further. An individual organism with recognizable mind is a space-time system which the energy-concept because of that mind fails to cover fully. In such an instance the two concepts prove to be complemental; the 'doings' of the organism *qua* organism cannot be followed by either alone. Each of the two declares that without the other its world is incomplete. It becomes indubitable therefore that our being is a unity whose behaviour we can follow only by including the two concepts and treating them as having 'contact utile' each with the other.

This serves to restrain trespass by one concept, however unwittingly, into preserves of the other. Thus, when Lucretius declaims that the mind is composed of little bits of 'matter' especially smooth to slip over each other quickly since the mind works quickly, we find him committing a crude trespass, driving the 'sense-concept' into the field of the non-sensual. The poet's fervour has overworked his favoured concept so far as to make it look a little ridiculous—in rendering things he has forgotten there is another besides Caesar.

When on the other hand the mind-concept is so applied as to insert into the human individual an immortal soul, again a trespass is committed. The very concomitance of the two concepts, which seems a basal condition of our knowledge of them, is thrown aside as if forgotten. Such amplification of the one concept may be legitimate for a revealed religion. Its evidence then rests on ground we do not enter upon here. But as an assertion on the plane of Natural Knowledge it is an irrational blow at the solidarity of the individual; it seems aimed against that very harmony which unites the concepts as sister-concepts. It severs them and drives off one of them, lonelily enough, on a flight into the rainbow's end.

That the concept based on the 'thinking I' should have spread itself, as the event showed, unduly, was natural enough. Finding it a solution of much, its partisans hoped from it a solution of more. That is the old urge in all of us, intent on relating phenomena, and for that purpose finding 'causes'. It turned the non-sensual concept to that use, and the more phenomena it could explain the more satisfaction was won from it. To 'explain' everything in one way is consistent, but one of the famous 'Maximes' runs: "le plus grand défaut de la pénétration n'est pas de n'aller point jusqu'au but, c'est de la passer."

So too the other concept, the spatial, or rather its devotees, have pressed it into fields outside its proper scope. The drive there too may well have been an unbidden urge toward Monism. The application of the spatial concept to phenomena alien to it was exemplified in the old speculative materialism of some of the Ionian Greeks. It represents a natural tendency which in no age has been wanting. It has done great service to Natural Science. Its immediate *raison d'être* has often been to dislodge intrusions of the other concept, the non-spatial, from positions, which the spatial concept representing 'matter' was by its advocates felt more adequate to explain. In this in recent centuries it has been triumphantly successful. It has made the energy-concept a weapon for man's conquest of the Earth. It has been potent in describing the perceptible, including the body and 'things' out to the limits of the perceptible. But it has had no success with the non-sensual, the 'I-thinking', its ways, and its creations, in abstract the 'mind'. Progress of knowledge, and especially of Natural Science, has only made more clear that the spatial concept's far-reaching notion 'energy' is, as it stands, powerless to deal with or to describe mind.

Not so long ago expectation was entertained by many that mind would with the growth of knowledge prove to be energy of some form, as yet perhaps not delimited. That is, it would range itself, in the language then customary, and customary often still, along with light, heat, chemical combination and other phenomena of energy. These are interconvertible, and quantitatively so. Not absolutely freely reversible, it is true; but yet their quantitative equivalence is measurable and ascertained. Thus, James Joule, arguing that something cannot vanish into nothing, found energy lost as work reappear as heat, i.e. 772 foot-pounds 'work' warms 1 lb. water at 55° F. to 56° F. There was an expectation among some that mental phenomena would on further knowledge come to be rangeable alongside these several manifestations of energy as one of the same series. Indeed the term 'mental energy' was not rarely used in that belief. This expectation has not been fulfilled. Further knowledge has not brought the two together. It has more definitely parted them. Language exhibits their disparation. The disparation lies, however, deeper than language; language merely displays it. Likeness between the two is only in the nature of metaphor. Thus the 'soul' at times is allotted 'shape' by metaphor, though for the most part of vague contour. Some of its synonyms illustrate this; 'breath', 'anima', 'spiritus'. We can understand that language should fall back upon the rich treasury of words pertaining to sense. Speech dealing with music resorts to visual imagery, because language is richer in visual terms than 'auditory'—by double or more. Fugues are 'architectural'; a passage in a symphony is like 'the veining of an autumnal leaf'. With the non-sensual its adjectives strictly are temporal only. Expression would have been impotent had it not trespassed into the sensual for imagery. To-day there is a tendency to stress 'mind' as dynamic. As metaphor this may be admirable. But it is prone to suggest that mind is 'energy'.

Mind, for anything perception can compass, goes therefore in our spatial world more ghostly than a ghost. Invisible, intangible, it is a thing not even of outline; it is not a 'thing'. It remains without sensual confirmation, and remains without it for ever. Stripped to nakedness there remains to it but itself. What then does that amount to? All that counts in life. Desire, zest, truth, love, knowledge, 'values', and, seeking metaphor to eke out expression, hell's depth and heaven's utmost height. Naked mind. We live at a moment hitherto unmatched, for our planet has just evolved mind in us to the pitch that we can take in our local situation of this present as we walk her side. Mind, yoked with life, how varied in its reaction! It will sit down and watch life acquiescent, or on the other hand take life and squeeze it like an orange.

And that other concept, energy; what of its yield? We saw that Time has winnowed its harvest too. How much remains? The perceptible world. All that the space-time continuum contains; gathered harmoniously into one category, a category which nothing which does not act on sense can enter and which all that does so act does enter. It sets us wondering whether what we sense can be just purely outcome of our mind. If so, it seems strange it should fall into so sharply different a category from all the other products of the mind. With this hint implicit in it, the perceived world is then our other concept's fruit.

Between these two, naked mind and the perceived world, is there then nothing in common? Together they make up the sum total for us; they are all we have. We called them disparate and incommensurable. Are they then absolutely apart? Can they in no wise be linked together? They have this in common—we have already recognized it—they are both concepts; they both of them are parts of knowledge of one mind. They are thus therefore distinguished, but are not sundered. Nature in evolving us makes them two parts of the knowledge of one mind and that one mind our own. We are the tie between them. Perhaps we exist for that.

XII

CONFLICT WITH NATURE

What! out of senseless Nothing to provoke
A conscious Something to resent the Yoke!

EDW. FITZGERALD'S *Omar Khayyám.*

A lover would not tread
One cowslip on the head
Though he should dance from eve to peep-o'-day.

KEATS.

Like as old Earth's, that lolls through sun and shade,
Our part is less to make than to be made.

ANON.

XII

By the kindness of a friend, a connection of Lord Gifford, there came to me some years since a copy once Lord Gifford's of the "Shorter Catechism" *. Within it a paper slip which had plainly long rested where I found it, lay at the page whose main paragraph opens, "Religion is of all things the most excellent and precious." Now, Lord Gifford in founding these lectures desired their subject to be "treated as a strictly natural science". Though the lecturer was not to be under restraint in dealing with his theme, "Natural Theology", he said, "I wish considered just as Astronomy or Chemistry."

His expressed wish was that in regard to Natural Theology the facts which seem relevant be followed as in Astronomy or Chemistry. Facts as hard facts we have indeed to try to follow whithersoever they lead. But the desire that facts of Astronomy or Chemistry and the like be taken in examination of, to quote his own words, "the relation which man and the universe bear to Him" "the First and Only Cause", is one less simple to fulfil. The difficulty arises that such facts are confined to the mechanical behaviour of electrons and similar elements and of aggregates of them. That must be so since the scope of those sciences is to describe those things in those terms. But direct bearing on the relation of man and the Universe to the First Cause may find little relevance there. More is demanded. There must be considered not only 'masses' and electric charges but such notions as ethical values, ideals and motives. In short the theme embraces as well as the perceived the percipient. That seems of its essence.

Today more than when Lord Gifford wrote, Natural Science is suspicious of the intrusion of the narrowly anthropomorphic into its view of Nature and tries as far as may be to exclude it. The perceptible is the subject matter of Natural Science, and the perception-process it uses is of course human perception.

* *The Confession of Faith and the Larger and Shorter Catechisms*, Edinb. 1744; p. 236.

Our Natural Science perforce looks at Nature through the medium of ourselves. But Aristotle of old judged rightly; evolution confirms him; there is, from the point of view of science, no fundamental gap between Man and Nature; Man is a part of Nature. Science, none the less, is anxious that the human viewpoint as part of Nature observing other Nature should not distort that other Nature more than need be. In earlier times man tended to 'anthropize', if the word may be allowed, almost all doings of Nature. Nature, thus anthropized, 'abhorred' a vacuum; its stone fell because a 'force impelled' it. Man inclined to read into Nature the feeling he experiences when, as he says, "he" moves his arm. He is a part of Nature; but he is only a *part*, and all parts such as he are specialized parts. To look at Nature as he looks at it must be a special and part view. Science desires to rid itself of 'anthropisms' as unnecessary. It inclines to regard what we think of as 'causation' as an anthropism. Our Fernel of the sixteenth century wrote, "we do not know anything until we know its cause". There the pen was Fernel's but the hand was that of Aristotle, becoming a dead hand. Today scientific description of sequences is less vocal about 'causes'. It contents itself with pure, if we may so borrow the term, 'behaviourism'. Astronomy and Chemistry, to take Lord Gifford's instances, deal in descriptions of 'how'. But 'causes' do not arise. To put to them therefore Lord Gifford's question regarding the First Cause is to obtain no answer.

Again, when Physics and Chemistry have entered on their description of the perceptible, life disappears from the scene, and consequently death. Both are anthropisms. Absolute beginnings and absolute endings there are none. Change from one phase to another is not in fact ending or beginning. There are no beginnings *de novo*. Absolute time disappears and so too absolute space. We see it is useless to address ourselves to this discipline for the relations of, to quote Lord Gifford, a 'First Cause'.

Natural Science thus attempts to withdraw itself from much that is human. It earlier shed the older anthropisms such as Olympus and the sky-children; but others tended to outstay them or to creep into their places. Observing the perceptible, the scientific observer tries to divest himself of 'causes', 'forces', 'absolute time', 'absolute space', 'beginnings from blank', 'endings in nothing', 'ultimate reality', 'life', 'death', 'personal Deity', to say nothing of 'hopes' and 'fears' and 'good', 'bad', and 'right', and 'wrong'. Science is neither bad nor good but only false or true. After all it suffers from the old complaint which Socrates proferred against Anaxagoras in the Phaedo. Man as scientific observer becomes an instrument for pointer-readings in the hand of a disembodied intellect.

Evidently therefore this science needs some liaison with the rest of knowledge. The more pure it is the more such need it has. It itself cannot approach Lord Gifford's theme. It has to find some medium before attaching itself to Natural Theology. It needs a liaison, and that Lord Gifford's own foundation seems able to provide something towards. Astronomy watching the starry furnaces at work forging and reforging atoms at amazing temperatures and pressures, does not ask them 'why' or whether it is 'well' or 'ill'. Chemistry following the pin's-head ball of cells transform itself into a child, to breathe and walk and talk among us, does not ask that pin's head 'why', or whether it does ill or well. Lord Gifford's philosophy would ask the 'wherefores' of such things; and so might we as plain men wish to ask. We might say, our inter-human contacts would often be relatively meaningless, unless we asked such 'wherefores'; then why not as between star and man or atom and man, just as between man and man?

Natural Theology, in the broad sense, as it has come down the ages has assumed many forms. It has articulated itself with the revealed religions, often, I would think, harmoniously, occasionally as though all but it were inessential.* At times, I would think, it has proved a ferment of doubt. Regarding it from the standpoint of a famous definition of it as 'that spark of knowledge of God which may be had by the light of Nature and the consideration of created things', the field it enters is a part of the field covered by the great revealed faiths. But in that common harbourage it is not secured by fixed anchors as are they; its anchor is the Natural Science of the time, an anchor con-

* E.g. *Theologia Naturalis, sive Liber Creatorum,* by Raymond de Sabunde; Paris, 1509.

stantly dragging. It in its day supplied the argument from Design, which later Hume, attacking it, declared, apart from revelation, the weightiest argument for a divine Cause. A traditional retreat of Natural Religion has been the cabinet of the physician. As to that, the remark of Rabelais, himself at once physician and in holy orders, was that where there be three physicians there will be two free-thinkers. And that old seventeenth-century book, *The Apology for Physicians* *, speaks of its being usual for the physician to be suspect of irreligion. Its author was Physician to Louis XIV, and the reason for the suspicion is, he declares, that the physician is led by his art to seek in Nature the causes of disease, so that the people say he kneels to Nature. Whereas, says the *Apology*, the true interpretation is that the physician knows from study of Nature that God is, and has created and rules all; his appeal to Nature is a resort to God.

There have over and over been definite cults of Nature which have invested Nature itself with Divine Powers. A definite and formally systematized cult of this kind which flourished long, and continued to do so until relatively lately, has been Astrology. It consorted ill with Christianity but it did consort with it. "If astrology believes in anything it is in the planets, not in God" had been a fifteenth-century remark.† Nemesis followed; astrology was slain by its own child, astronomy.

Faith also, of course, had its own communings with Nature. Religion, building in piety the great cathedrals, loved to dwell on details in familiar nature. It loved to adorn column and roof-tie with representation of flower and leaf. It drew lessons from Nature and loved to find in natural things symbols of ethics and its faith. The industry of the ant, the thrift of the hive, the beneficent sequence of the seasons, the wisdom of God in the dispensation of Nature.

To some of these pious readings of Nature changing science brought disillusion. Had Hume lived to 100 years later he would have seen the argument from natural design which he had

* *Apologie pour les Médecins*, Ch. Lussauld, 12mo, Paris, 1663, reissued again early last century by P. J. Amoreux, Montpellier, 1816, 8° (see also *Lettres de Guy Patin*, Lett. 352. 618.)

† Pico della Mirandola, *Disputationes adversus astrologiam*, Bologna, 1496.

so wrestled with and against, replaced by views of living Nature bleaker and sterner even than his own. The new point of view heightened the intelligibility of much, and with that perhaps the mystery of the whole, but it cast a shadow over St Francis' exultation in Nature as a brotherhood.

Human knowledge today faces Nature disabused of Christendom's one-time view that, apart from the intermeddling of unblest magical powers, Nature is in all ways all for the best. There are those who can be at ease in the paternal hand of God. St Francis could. A short 400 years, which we took here as our interval between 'then' and 'now', has travelled somewhat far from the acquiescent faith in Nature which we can read in Jean Fernel. Today, knowledge views the natural scene wide-eyed. That fact of itself is one great change since then in the human situation.

Science is today more aloof than in Fernel's time from the standpoint of Raymond de Sabunde and a natural world which, looked at by the moralist, assured him "from every nook and corner that a loving Father had devised it, loving what He had made". It is perhaps nearer to the judgment of Philo in Hume's Dialogue. "Look round this universe. What an immense profusion of beings animated and organised, sensible and active! You admire this prodigious variety and fecundity. But inspect a little more narrowly these living existences. How hostile and destructive to each other! How insufficient all of them for their own happiness!" The science of today equipped with newer knowledge submits nakedly the facts for judgment.

Today's newer knowledge looking at Nature finds there as wrote Aristotle, "evil is more plentiful than good; what is hateful is more plentiful than what is fair". He added, devoted naturalist, the tiny parable; "a philosopher once explained the key to this as 'love' and 'strife'". Nature is a scene of interaction, and between living things interaction can be co-operation or conflict. Nature exhibits such co-operation but she is burdened with conflict like a nightmare. Unhalting and blood-stained conflict systematically permeates the field of Nature. Beauties it presents, joys it contains, but a blight of suffering infests it. For that reason whole fields of it are sombre tracts to contemplate.

This view might seem in some sort a return to a view of Nature which, at least once earlier, has prevailed. In patrician and imperial Rome there supervened as regards Nature a phase of disenchantment and revulsion. It prevailed along with a materialistic attitude. Dr Singer (*Science, Religion and Reality*, London, 1925) has briefly but, I think, very memorably depicted an impression given by the scientific background of that time. "In our age men learn the ways of Nature that they may control her, but the time for that was not yet. Epicurus would have us know only so much about her as would remove from us all fear of super-natural interference. Stoic and Epicurean literature show therefore in later antiquity a flagging of scientific curiosity. Men were weary of the world." "Science linked with Stoicism assumed a fatalistic and pessimistic mood." The Stoic Emperor mused. "Thou hast subsisted as part of the whole. Thou shalt vanish into that which begat thee, or rather thou shalt be taken again into the Seminal Reason by a process of change." (*Meditat.* IV. 14.) Such philosophy viewed Nature askance and sullenly as a tyrant. "'God, if God there be, is outside the world and could not be expected to care for it', says Pliny. 'Deity only means Nature.' It was an iron, nerveless, tyrannical Universe which Science had laid bare and in which man felt himself fettered, imprisoned and crushed. For what reason should man seek to know Nature more intimately? Nature, the merciless, the tyrannical, the cruel." "Science had induced that essential pessimism which clouds the thought of later antiquity" (Singer). Our own seventeenth-century essayist put his finger on the essential cynicism of patrician Rome when he wrote: "'What is truth?' said jesting Pilate, and would not stay for an answer."

The materialism of that time was however radically different from the scientific materialism of today. The atomism of today is no untested *a priori* speculative dogma. It is unrelated, except by misnomer, to its namesake of antiquity. That materialism of antiquity sat and looked at Nature, impotent to deal with her. It made her a thing to stare at and despair. The reasoned materialism of today is on the contrary an inspiration for dealing with Nature.

Evolution is a dominant note in the message which today hears from Nature. A great field for the play of evolution is that of the interaction between one living thing and another. That interaction can, we said, be co-operation or conflict. There is for instance the fairylike visiting acquaintance between the planet's population of insects and its population of flowers. The insect cross-fertilizes the plant and the plant feeds the insect. It is a partnership which cannot be very ancient as the age of life goes, for the flowering plants are not very ancient. The alliance has been fruitful for each partner. It has, we may think, contributed to develop floral form, floral colour and floral scent. To the insect it has brought means for reaching nectar and pollen and, we must suppose, developments of mentality, certain wonders of instinct with percipience, and purposive action. Otherwise it is difficult to see how floral form and colour would have had survival value. True, it may be questioned whether any ray of intellect enlightens the association. Instinct *ad hoc* but perhaps that is all. Our point here is however that it is an association between two wholly different lives where both benefit. That is indeed something. Association between two different lives is common enough, but not for the benefit of both. Let us turn to an instance which offers strange comment on Raymond de Sabunde's "every creature is a written letter declaring Goodness". In it Nature associates three lives, not to the 'good' of all.

There is a small worm in our ponds. It starts from the ripe egg as a little thing with two eye-spots and between them a tiny tongue-shaped bud. It travels about the meadow-pool as though looking for something. Living in the same pond-water is the pond-snail, with its delicate spiral shell. This it is which the tongue-headed worm is anxious to meet. It has only eight hours to do it in. Given success, with its tongue-head it bores into the lung of the water-snail. There it turns into a bag and grows at the expense of the snail's blood. Its cells which line the bag make individuals, each simplicity itself. A gullet, a stomach, some glands and a genital pore. This is the Redia, named after Francisco Redi, the accomplished Italian naturalist and antiquary. The cyst in the snail's lung is full of Redia. They bore their way out and wander about the body of the snail. They live on the body of the snail, on its less vital parts for so it lasts the longer; to kill it would cut their sojourn short before they could breed. They breed and produce young. The young wander within the sick snail. After a time they bore their way out of the dying snail and make their way to the wet grass at the pond-edge. There amid the green leaves they encyst themselves and wait. A browsing sheep or ox comes cropping the moist grass. The cyst is eaten. The stomach of the sheep dissolves the cyst and sets free the fluke-worms within it. The worm is now within the body of its second prey. It swims from the stomach to the liver. There it sucks blood and grows, causing the disease called 'sheep-rot'. The farms infested with it are termed 'sheep-sick'. The worms inside the sheep's liver mature in three months and produce eggs. These travel down the sheep's liver-duct and escape to the wet pasture. Thence as free larvae they reach the meadow-pond to look for another water-snail. So the implacable cycle rebegins.

It is a story of securing existence to a worm at cost of lives superior to it in the scale of life as humanly reckoned. Life's prize is given to the aggressive and inferior life, destructive of other lives at the expense of suffering in them, and, sad as it may seem to us, suffering in proportion as they are lives high in life's scale. The example taken is a fair sample of almost countless many.

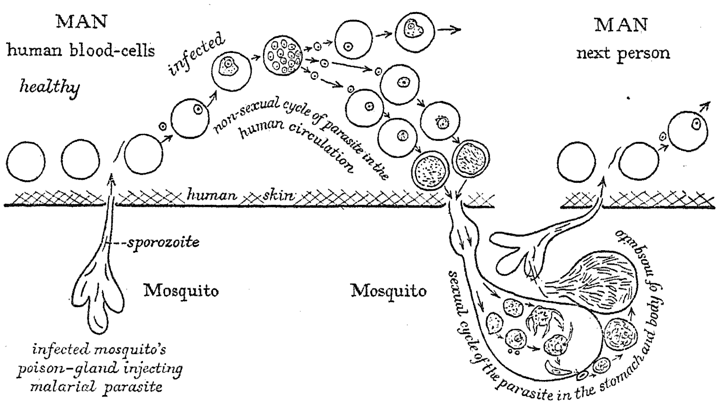
We may take one more. In some ways it is simpler than the last. There is a gnat, called *anopheles*, from the Greek word for 'hurtful'. Many gnats have the mouth armed with stabbing and sucking styles. So this one. It stabs the skin and draws blood. There is an 'anopheles' with dappled wings. It bites men. Only the female bites. She has eggs to nourish. She takes human blood once a day. She then flies to a shaded corner. For instance having bitten some inmate of a dwelling, shaded for coolness in the tropics, she then settles in a dim corner of it to digest her meal.

The so-called 'bite' happens like this. The gnat when she alights on the skin tests the place with her labellum. Then steadying her head against the skin she stabs by styles with dagger points and saw-like edges. Swaying her head as she uses her mouth-parts she works these through the skin. They go through and among the blood-vessels, and carry with them a tiny tube like a hollow needle, close behind the stabbing style.

It leads from a poison-gland. It injects a droplet of juice into the stabbed wound. This makes the blood-vessels flush; they bring more blood to the stabbed spot. Also the juice delays the clotting of the blood which might baulk the gnat of her full meal, by cutting short the yield of blood from the tiny wound. Nature has provided her with special tools and a special zest for thoroughness. She sucks the blood by a tube which leads straight to her stomach. Rich food it is, human blood. Besides fluid it has two kinds of cells. We have to go into that point. One kind is the red cell (Plate IV, top), 5 million to the cubic millimetre of blood; they give the blood its crimson colour.

The red cell is one of the most specialized of all our body's cells, so specialized that like the worker-bee of the bee-colony it has no reproductive power. It carries the great respiratory pigment, haemoglobin, not unrelated to the green of the plant-world, chlorophyl, the key to the carbon cycle of life. It is a complex of linked pyrrole-rings with attached iron. It operates the enzymic respiration of the animal. It in its way is not less important than even chlorophyl. Its way, in very brief, is this. Oxygen is said to 'wind the vital clock'. It does so for every cell in the body. The haemoglobin of the red cell is the carrier of oxygen to every cell in the body. The haemoglobin is then continually returned by the heart to the lungs to be reladen. So the cycle goes on day and night, life-long. Over and above that the red cell carries the body's great waste-product, carbon dioxide, to the lungs to be breathed out. This, the red cell, is the chief cell of the blood, but there are others (Pl. IV, top), which, as we saw before, digest food-particles and invading germs. All these together are drawn up into the gnat's stomach and are digested there.

The little drama of blood-sucking is not idyllic; but it is a clean bill compared with what may happen, and does only too often. Our dapple-wing gnat when she 'bites' her human quarry, and injects as always her droplet of juice to make the blood flow better, may be healthy, or she may not. She may be infected with the parasite of malaria. In herself it seems to do little or no harm. She is what is called a 'carrier'. The parasite swarms especially in her poison-gland near the gnat's head. The droplet of juice which the infected gnat injects swarms with little spindle-shaped wriggling creatures, the sporozoites of *plasmodium*, the microscopic parasite of malaria. These enter the circulation of the 'bitten' person where the tiny blood-vessels have been laid open by the bite. Thus they are let loose within the circulating human blood. Then tragedy ensues. They lose no time. They attack and enter the red cells (see left-hand of figure). Inside the red cell the parasite which has entered it sits quiet at first, a very minute amoeba-like thing. Later it crawls about in the red cell, the living house it has seized and is to ruin. It gradually eats out the inside of the cell, and it grows. When it has eaten out the



whole of the human red cell it splits up into a family of young. The killed and distended red cell bursts and lets them loose. Released into the blood each of these young ones in its turn attacks a red cell as its parent did; it enters, grows and eats the red cell's heart out, repeating the old cycle.

What, we may ask, are our own amoeboid cells of the blood doing, they, so efficient against invading germs? Well, we remember they do not attack their own fellow-cells of the blood, the red cells. The malaria parasite seems safe when once it is within a red cell. It is, so to say, 'camouflaged' there. The amoeboid blood-cells do find a few and do devour them, but not enough to count against the mischief.

This is a grievous disease. Burning fever every fourth or every other day or even every day until the sufferer worn out and weary loses all heart and strength. The period of this cycle is set by the life of the parasite. The break-up of the sick red cell lets out the family of young parasites and sheds into the blood-stream poisons which give fever. Since the whole of the parasites in the blood ripen together, all the millions of infected red cells break down at the same time. The sufferer is suddenly flooded with poisons and with the millions of broods of the fresh parasites. Hence each fresh paroxysm of fever.

Suppose that in every hundred red cells the infected ones amount to four. Then every third day let us say Monday and then again on Thursday and then again on Sunday at about the same hour four per cent of all the red cells in the sufferer's blood break up. That is, about a million million red cells in his blood break and shed poison and let loose some ten times that number of young parasites into his blood, to start work there again. And this repeats itself. Each repetition is for the sufferer a day of paroxysmal fever. At first he shivers, with shivering that will shake the bed. In 20 minutes he is less cold. Shivering stops. He throws off his coverings. He begins to burn. He becomes burning hot. His temperature runs to 103°. Then after some hours at last perspiration comes. His fever falls. Utterly exhausted he drops asleep. Three days later it will be all to be gone through again.

In the 10 hours of a malaria paroxysm 10% of the total red cells may be destroyed. And this every third day. The constitution cannot cope with such loss. Faintness and distressed heart and difficult breathing follow. Dead red cells and living parasites may actually clog the smaller blood-channels of the heart and brain.

In this struggle between the parasite and the man a time comes when the parasites prepare for a new phase, sexual reproduction. In each red cell the parasite turns into an immature sexual form, male or female. At this stage instead of bursting the eaten-out red cell, *plasmodium* lies low and waits. For it things are at an impasse, which may be fatal to it. It cannot conjugate for two reasons; it is not mature, it is inside a red cell and alone. It waits. It waits for an incident which, contrasted with all the apparent strategy which has carried it so far, seems strangely haphazard. The two sexual cells, each futile without the other, are shut apart in separate red cells which they have eaten out. Their chance of meeting depends on a fortuitous agent. Not in this case, as so often in Nature, inanimate wind or stream but an insect, again our dapple-wing gnat. She 'bites' the malarial sufferer. She sucks from him her blood-ration. The sick red cells in that ration contain these immature sexual phases of the parasite. These latter instead of being digested by the gnat's stomach enter there on a climax-phase of activity. They are of two forms. One rounds itself into an egg ready for fertilization. The other protrudes four or five lashing tails, each with a tiny nucleus. These tails break off from each other and swim away. They are ripe sperm-cells. They find the ova ready beside them in the gnat's stomach. They fertilize them. The fertilized egg then lengthens, and becomes pointed at one end. This pointed thing wriggles toward the wall of the gnat's stomach and enters it. There it settles down. But it grows. It becomes a bag filled with a brood of delicate sickle-shaped cells. Distended with hundreds of these the cyst bursts. These are let loose into the gnat's blood, in the spaces of the body of the gnat. The parasite is back therefore in blood; taken from human blood it is now in gnat's blood. It swarms there in its thousands and especially it swarms in the poison gland at the gnat's head. Ten days from its mating in the stomach of the gnat the parasite has completed its sexual cycle and is in the gnat's poison-gland ready when the gnat bites, to infect with malaria a fresh man or woman or child.

This parasitic animal scourges with misery and death entire regions of Earth's surface which might but for it be happy places. A poet who had seen much of it called it 'million murdering', and that is true. Its life is the destroying of other lives, and it infects nearly one-third of Earth's human population. It is a product of evolution. Evolution has adapted it, complexly, delicately and effectively to kill other lives. Since it requires man for its slaughter it would seem an evolution of recent date. Its hideous cycle has overcome with 'ingenuity' great obstacles to perpetuate itself. For instance, from within the gnat's stomach it must win its way to the poison-gland. How does it know the poison-gland? Perhaps a chemotactic principle directs it thither.

Then the moment comes, or may never come, when the gnat's beak enters human blood, and inserts into the man the parasite. Three things are then open to the parasite. The rich liquid of the blood, the red cells, or the other cells of the blood. The parasite hesitates not a moment. It does the right thing. It chooses the red cell. Then it is safe. It reshapes itself and eats. 'Trial and error' is a term commonly applied to the 'random' action of an animal, say a rat, faced with the situation of, for instance, food set in a cage the opening of which is unfamiliar to it. It noses about or paws in various ways, and persistently. A lucky movement gives the needful operation of a latch or hinge. A few repetitions of the test and the lucky movement is, it is claimed, stamped in, as 'acquired behaviour'. Here we think of the unrest underlying the random movements as indicating a mental condition, conation, 'trying'. There was in the rat, may we not think, also a mental motive, with its glimpse of futurity. Besides in the rat there are some degrees of conceptualizing. A rat learns to distinguish between a triangle and a square independently of size, lighting, orientation or surround. The malaria plasmodium is a single cell. We saw reason to doubt whether any single cell, either part of an organism or a complete organism in itself, can have mind read securely into its behaviour. And here it would require for meeting its problem successfully, as it does, sensing and perceiving, cognizing and judging; reason, intention and forecast of future, not to speak of recognition and choice. If it had those it would assuredly vary its acts and ways more than it does, and would try new methods. Accepting however a skilled observer's description* of his infusoria as exhibiting the method of 'trial and error', even that attribution does not take us far enough with plasmodium malariae. Plasmodium, after a series of spore-generations billeted within the sick man, suddenly prepares for sexual generation. That will entail waiting ready for the coming of the one agent which can afford it the one place in all the world where its sexual phase can complete itself. This seems a situation more complex than that facing infusoria feeding in a drop of water under the microscope. If it is mind which deals with it, then it seems to presuppose in that mind knowledge of the existence of the gnat and of man and of the ways of both, at least in so far that the former sucks blood from the latter.

* H. S. Jennings, *The Behaviour of Lower Organisms*, p. 243.

Again, from the gnat's stomach it must escape and win its way to the poison-gland, that organ of the gnat which of all its organs is the only one which can transfer it to the human host necessary for the next stage of its cycle. How does it know the poison-gland? All we can say, and we have said it, is that perhaps a chemotactic principle directs it thither. The whole cycle at whatever point we take it seems a plan which all the steps of the behaviour of plasmodium conspire toward, and each step seems to imply anticipation of what follows. So purposive in appearance is it that description of it by the naturalist and the physician lapses unwittingly into language that supposes mental behaviour on the part of the plasmodium. "Each merozite tries to enter a red cell." "The microgametocyte waits till the mosquito bites."* But we can take another line of thought. We may say the creature which benefits by the scheme is but expressing a purpose, not of its own conceiving, but of the Design which runs traceably through Nature. With attribution of that kind to Design runs attribution likewise of infinite Knowledge and infinite Power. When recourse is ventured to such hypotheses and to such attributions, we may think that the boldness indulged should carry with it appraisal of the purposive plan. Obvious frailties are seen to attach to some steps of the life-cycle of our plasmodium malariae. Certain haphazard methods risk wrecking its 'design'. Thus, the immature sexual forms can exist in the human blood only a very limited time; the scheme depends on the chance that the right gnat—the female Dapple-wing—will bite within that time. There are those who judge of natural phenomena as if conducted in every instance according to what they themselves, were they to design it, would believe to be reasonable and right. It is a view which implies that a purpose has always to be found and that purpose one which bears the mark of beneficence. But that amounts to withdrawing the thesis from critical examination. The more open mind would feel that in the case of *plasmodium* v. *homo* beneficence espouses the wrong cause. There still remains however the mechanical point of view. It says, a genetic system which meets a need of the organism provides in so far the mechanism for its own survival.

* Castellani and Chalmers, *Manual of Tropical Diseases.*

Malaria is the fever Homer told of. Only after the fifteenth century when the great navigators had revealed the extent of the globe, did Europe begin to learn the extent to which this fever ravages the Earth. Today we know that in India alone it kills about 1,200,000 persons each year. For each person dying there are of course many ill. In some districts of India the entire population is ill with it. The quantity of human suffering and misery is beyond our actual appreciation. Nature has evolved in this plasmodium a means of inflicting pain and distress to an extent calculable but practically unimaginable. In that respect a dozen others of like kind compete with it for pre-eminence. It was in despair of Nature as any fountain-head for the moralist, that Matthew Arnold wrote: "Nature is cruel; man is sick of blood: Nature and man can never be fast friends;" which is true enough, though in its brevity it may seem a little shallow.

In Hume's Dialogue the character Cleanthes offsets the pain to be found in Nature by co-existent equivalence of pleasure. Malaria is a chapter of biological knowledge new since Hume. What equivalence between pain and pleasure could Cleanthes trace there? Men, women and children by the million suffering distress even to death. For what? To feed a thing not much unlike an amoeba of the pond, a protozoan parasite. Can we by any flight of fancy conceive that this speck of organized slime embodies a grain of pleasure? The mere suggestion, even if unwittingly, rings like a callous levity when heard against the groan of a tortured population.

Naïve thought might suppose the scheme of Nature would at least value transcendence in life, e.g. a man more than a protozoan speck, or than a parasitic bacillus. But no. Of these latter that thrive by killing the former there are kinds too many even for mention here. There is, for one, that lowly and destructive life, the tubercle bacillus, which martyrs men and animals the habitable globe over. A hundred years ago John Keats, the poet, equally young and great, succumbed to it at the age of twenty-five. It had destroyed his lungs. Of his last book, the year before his death, there was said not long since by an exacting critic, "the more I read it the more disposed am I to think this book to be, of all the world's books, upon the whole the most marvellous." * Keats had, in vain, nursed his younger brother attacked by that same venomous speck, and was in turn infected himself. The story is one of inexorable tragedy, nobly borne. Of Cleanthes' countervailing compensation where is here any? Fate in the Greek tragedy was inexorable by divine nature. But here it is inexorable by mere chemistry? It is for man as critic and censor to interfere.

These venomous specks and others like them are sustained at cost of an immense sum of human suffering. To Hume's good Cleanthes the fact would doubtless be strange as distasteful. It seems truliest faced by recognizing that Nature, though she has evolved life, makes no appraisal of it. She has no lives of higher worth or of lower worth because to her all lives are without worth. If she is purely an assembly of mechanistic principles how should she appraise? Hume makes his character Philo inveigh against Nature "pouring forth into her lap without discernment or parental care her maimed and abortive children". Today a geneticist speaking of evolution tells us that the majority of oncoming mutations are lethal to their individuals. But to Philo's suggestion that Nature is immoral, today's reply is 'non-moral, not immoral'. Design or no design, some will say, and perhaps Hume would be among them, it is for man in reliance on his own dictates to take sides in this battle between life and life. Aristotle found in Nature 'unconscious purpose'. Read by evolution, Nature, now containing higher animal life and man, begins to contain a certain conscious purpose.

Granted the scope of natural science be to distinguish true from false, not right from evil, that simply makes the man of science as such, not the whole man but a fractional man; he is not the whole citizen but a fraction of the citizen. The whole man now that his mind has 'values' must combine his scientific part-man with his human rest. Where his scientific part-man assures him of something and his ethical part-man declares that something to be evil it is for the whole man in his doing not to leave it at that. Otherwise in a world of mishap his scientific knowledge and his ethical judgment become two idle wheels spinning without effect, whereas they have been evolved and survive each to give the other effect. But for that he would

* H. W. Garrod, *Keats*, 1926, p. 62 (2nd ed.).

not have them. Without that will he retain them? If he prize them he must use them, or Darwin might tell him he may lose them.

To man looking round dispassionately there is both what rejoices and what saddens him. There is the lovable in life. "Et je ne verrai plus les riantes Cyclades"* has often been life's sigh ere departure. "Oh me, oh me, how I love the Earth, and the seasons, and weather, and all things that deal with it, all that grows out of it", wrote William Morris, socialist and poet. What is it then that poisons Nature? If man could answer in one word that word might be, I think, the cruelty of life.

We look into the scene of living Nature now with a knowledge more competent than was at the disposal of Jean Fernel. Moreover our scrutiny has for us an interest livelier and more poignant than for him his had. Its features appeal now as they could not to Fernel, and for a reason Fernel would not have guessed. We look now into that world of other life which still jostles our own, and do so with the new-found knowledge that it is a world whence we have come. We are still in continuity with it, but, not so long since, as out planet's ages go, we were immersed and submerged in it, a part of it not unlike all the rest. Such satisfactions and miseries as we can descry in it were then ours too. They were then our lot in life. It is a picture to depict which from the inside defies our power. To relive it in imagination is beyond our imagining. So far as it was experienced—and we can scarcely gauge what capacity for experience we had then—it was experience the like of which we have not now, even in faintest remembrance. If we try to re-imagine it, all that is possible for us is to 'anthropize' it, and then we find it an inhuman dreariness broken by nightmare irruptions of the hateful and the horrible. We can equivocally read into it perhaps the satisfactions of the pangs of the hunter hunting food and, too, the privations. There were the miseries of the hunted, those too were ours. Studying that other life we do so now with the knowledge that its lights and shadows are of the kind and order of those through which our infra-human history brought ourselves, clambering to man's estate. Remembered they are not.

* J. de Heredia.

Man's memory never took part in them. But gazing at the scene his knowledge can as it were reseize some features of it. It was a life of the passing hour containing little yesterday and little tomorrow. Its past and future mentally were thin streaks. Its 'now' like a moving spotlight played over an almost or entirely non-conceptual world discovering relatively little and ranging relatively little. Its world was wanting in variety, for it was mainly meaningless except at points where it touched food or sex or danger. Its peak perceptions were food, sex and danger merged with motive passions operated instinctively. Its life's objective compared with man's that covers a whole daylit horizon, amounted to hardly more than a single point or so. Its world treated life mainly as efficiency to escape death. Its world was under a rule of 'might-is-right' imposed by violence and pillared upon suffering. But yet the spell of 'urge-to-live' was over it all. Repicturing that life, so far as we can, we marvel and rejoice at our escape. The factual history of our past indeed is almost antithetically remote equally from the pagan myth of man's descent from the Gods, and from the wishful poet's 'intimations' that "trailing clouds of glory do we come". Truth however has the compensation that it is true, and here further that it would seem more pregnant with promise than were either of the fancies.

Life by its nature is linked with growth, and, since individual life soon reaches its size-limit, growth if it is to go on must proceed to multiply the individual. If life self-catalyses its own growth, growth must go on, and individuals must be multiplied. For evolution there can be no other life than life which grows. Lives then, since their business is to live, find themselves in situations where there is not enough for all competitors for sustenance. Some lives will therefore hamper or exclude others. There is in fact competitive conflict.

A practical conclusion which everyday experience draws about life, though quiet reflection in the study may challenge it, is that some life is accompanied by mind, and some is not. The whole plant world we recognize as alive, but even to crowning instances of it, such as tree and flower, our practical everyday thinking does not attribute mind. They have life but not mind. The pragmatic position is then that we distinguish between life and mind. So then we ask 'what is this life', for instance of flower and tree, devoid as it seems of mind? The answer to which our facts impel us is that this life, for instance of flower and tree, is chemico-physical behaviour; the behaviour of those chemico-physical systems which we call 'alive'. They are each individually a complex of systems practically integrated to one system. Such integrated chemico-physical systems 'live'. The living plant-virus is such a system at its minutest, and is chemically crystalline. These chemico-physical systems with their demands for replenishment from the 'field' 'compete' for their replenishment. Since it is competition for life, it involves death. Mindless competition as it is it does not connote suffering. Man when he employs such lives, and tasks or sacrifices them, is not doing otherwise than when he employs other machinery, for they are machinery. Life in so far and per se would seem no sacred thing.

Where mind is discoverably attached to life, mind enters into the competition between life and life. Finally the competition will enter an ethical plane. I have no semblance of claim to moralize. This is but datum for a moralist. The competition between lives which have mind is in origin one with that between the so-called mindless lives of which we were speaking. It overlaps and dovetails in with that and continues it on the new plane. It also, because a struggle to live, is essentially a struggle to the death. Seeing that the mindless life maintains its living, promotes its living, rescues its living from destruction, even from threat of destruction, feeds, grows, propagates, in short acts as though its living were its most precious possession, we figure in it an innate 'urge-to-live'. In lives which have discoverable mind, it is as though mind implements that 'urge-to-live'. Mind, as it evolves, endorses unequivocally that old innate viewpoint. We can call it then 'instinct of self-preservation', etc. As mind develops further there accrues greater wealth of behaviour directed toward that aim. The individual life in virtue of its mind uses strategy to promote its life and that of its seed, and strategy to avoid death. To the unconscious 'urge-to-live' is added conscious 'zest-to-live'. It is a life which *would* live. The 'conservation of self' is, Dr Charles Myers* tells us, a

* *Realm of Mind*, pp. 175, 251 (1937).

principle in psychology as real and important as the physicists' principle of 'conservation of energy'.

It would seem that evolution safe-guards and cultivates this 'zest-to-live'. The 'selfishness' which was unconscious becomes when armed with conscious mind still more efficient. It can be a ruthless 'will' that self shall live at whatever cost to other lives. It has a favourable field for development in the scramble for a means of living which Nature offers. When mind informs the struggle it can become fraught with suffering. In contrast with wild Nature man's measures of domestication resemble something of a peace imposed on Nature. It was a strange misapprehension on the part of Rousseau that the native state of Nature is a peace. Nature in the primeval African forest as observed by a versed and sympathetic naturalist of today* is found to present an appearance 'sinister, hostile and horrible' (Preserved Smith†).

An element deepening this conflict is that Nature has evolved kinds of life whose specific food consists of lives adjunct to developed mind. This obviously continues, heedless of mind, what prevails in the mindless competition between lives where one life battens on another. It suggests that Nature holds mind at a discount; perhaps she is so fertile that she can afford to. Developed mind as agent of predacity always offers the paradox that 'zest-to-live' develops as its corollary 'zest-to kill'. It demonstrates life condemned to live by spreading pain and death around it. Whatever meaning the evolution of life and mind may have, mind so soon as it develops is plunged into the thick of life as conflict. Where the predatory life and its quarry both possess developed mind the struggle leaves a trail of suffering. The predatory life which so lives is a seed of suffering on the planet's side. Nature contains much which is hateful and much of pain. Much "that spoils the singing of the nightingale".

In this conflict mind can enhance both the attack and the defence. One strategy for which it is enlisted is organization of individuals into a defensive or an aggressive community. The herd, the flock, the hive, groups of related individuals with

* Julian Huxley.

† *History of Modern Culture*, vol. ii, p. 624 (1934).

interests in common, organized on a peace-footing, the individual as unit contributing social safety and support to the community of units. Under this organization the mind gradually evinces new qualities of the 'self'. Zest-to-live takes on new aspects. Thus, in our own human kind altruism, extending to the family and beyond, to the tribe and beyond, knitting social ties of planet-wide comradeship and goodwill. Love-of-life extends, so to say, to beyond 'self'. It is sublimated to new aspirations, which in their fullness grow strong and dear as love-of-life itself—pity and charity and love of others and self-sacrifice, even to sacrifice of 'love-of-life' itself.

In antithesis to this there is the other type of living, the predatory. It has prospered and has prospered hugely. It has brought into existence and maintains in existence countless millions of lives which otherwise would not have been and but for it would forthwith perish. It has produced beautiful types of form and motion. It attaches a premium to 'zest-to-live' as 'lust-to-kill'. It developes its own gift of killing to heights of skill and ingenuity which astonish. The predatory type of life even where endowed with developed mind is more often a non-community life. It brings, and this may be regarded as inherent in it, little progress in social organization. Yet it does show instances of such organization, the wolf-pack for example. But outstanding developments of the predatory type—hawk, eagle, leopard, tiger—are not community lives.

In elementary forms of life not evidencing mind, if the right to extinguish them be questioned we can at least reply, to do so inflicts no suffering. Where to destroy life, to injure it, is to inflict pain and distress, the 'higher' the life preyed on the more the suffering inflicted. The curse of suffering under the predatory régime ingravesces as we follow it upward in the scale of life. As life progresses the predatory régime is thus a curse which grows a graver curse. That should in itself promise ultimate relief in the form of limitation of the régime. The higher the type of life attacked as quarry the greater the toll of suffering that quarry pays, but also the more likelihood that, since it has mind, the incentive to, and the ability of, the quarry to free itself from being quarry will succeed. The scheme in short disenables its own extension upward; that is in fact instanced by the phase which man as quarry has entered. He has hedged himself with a 'pax' which much that is predatory respects. True, the predaceous in Nature does still destroy him in great numbers. They still attack and feed on him, and breed within him, and, we have seen, torture him and kill him in millions yearly. But he has in recent times turned his mind to improving his defence. His defence lies mainly in attack. He has set himself deliberately to exterminate those lives which invade and incapacitate and destroy his own. There his policy raises again the question, 'Is life a sacred thing?' Is it the right of rational life which has the 'values' to destroy life? Is that not a trespass against the Spirit of Life? The Spirit of Life! That is what we set out to find. We could not discover it. We have not found it. Wherever we looked for it it vanished. We know no Spirit of Life. Life is a chemical complex with certain ways of its own, chemical not the less for that. Is life a sacred thing? Life a sacred thing! Life taken in general can be no sacred thing. It has enslaved and brutalized the globe. True, life is the supreme blessing of the planet; none the less it is also the planet's crowning curse. If the planet would secure for its community a living welfare on its surface, in that aim it finds itself thwarted and tortured by unstemmable fecundity of lives teeming in backwaters of blind 'urge-to-live'. The planet has to be rescued from such 'life'.

We see that if, apostrophizing Nature, we ask her the question, clearly she says, 'life is no sacred thing'. But we are doubtful whether in our sense she has 'values'. Addressing then the question to some neighbour he well may tell us:—this much is clear; where life has mind, life can suffer; it is suffering which counts. Where life ranks highest, there it can suffer most. Human life has among its privileges that of pre-eminence of pain. The civilizations have not rarely ruled that among lives one life at least is sacred, namely man's.

We think back with repugnance to that ancient biological pre-human scene whence, so we have learned, we came; there *no* life was a sacred thing. There millions of years of pain went by without one moment of pity, not to speak of mercy. Its life innately gifted with 'zest-to-live' was yet so conditioned that it must kill or die.

For man, largely emancipated from those conditions, the situation has changed. The rule and scene are there, and are the same, apart from himself. The change is in himself. Where have his 'values' come from? The infra-human life he escaped from knew them not. The great predaceous forms, shark, hawk, panther, wolf, are not blind; they mean the things they do; they have been given mind. But not with values. 'Wrong' is impossible to them. More hopeless still, equally impossible is 'right'. Those other creatures than himself, even the likest to himself, would seem without the values, or it may be at most some 'value' *ad hoc* for a given situation. Nothing of values as concepts such as are his, constantly vouchsafing him counsel in situations however variously circumstanced. Whence has he got them? Inventions of his own? Conventions? How far can he trust them? Can *a priori* principles suffice to base them? Are they heritable? They are under test. They are in the making, even more than is the rest that he is.

He feels afresh that in himself for the first time a product of the process of evolution perceives that process and reads its own making. It is as though the door of Nature had been pushed ajar and man were peeping through, there to get a glimpse at his own story and some fresh understanding of himself. His reading of the world and of himself in it had before been a different one. In several ways his fuller knowledge has spelt disillusion, disenchantment. In him evolving mind has got so far as to become critical of life. He feels the curse as well as the blessing attached to 'zest-to-live'. He is impressed by a cruelty inherent in the economy of life. He is disillusioned the more to find he is a part in that same dispensation. The régime is, if he ask his 'heart', one for which he cannot seek his heart's approval. There was the old parable of the Fruit of the Tree and the Expulsion from the Garden. With knowledge of good and evil, paradise was lost. To look on with understanding at what is passing in life's world and to be a party to it is complicity in war against his 'values'. Lessons from the old sub-human existence enjoined on him at least what to avoid. But ancient trends die hard. He himself is often still just one more agent of suffering to others. He must escape further from those ways of life. He must try to shed from his gene-complex some sub-human ingrained elements. The mill he has been through ground out its products in the main by retaining above all the interests of 'self'. He was a successful product of that process. Looking at it, as the founder of these lectures would in these lectures have him, by that same mode of thought which he employs for science, but infusing into the view so won, as again the founder of these lectures would have him do, his moral aspirations, there arises for him a dilemma and a contradiction. The contradiction is that he is slowly drawing from life the inference that altruism, charity, is a duty incumbent upon thinking life. That an aim of conscious conduct must be the unselfish life. But that is to disapprove the very means which brought him hither, and maintains him. Of all his new-found values perhaps altruism will be the most hard to grow. The 'self' has been so long devoted to itself as end. A good man's egotism, it is said, is altruism. Perhaps that indicates a stepping-stone on the way.

Nature, if the energy-concept subsume her, is non-moral, not immoral; the irresponsible is not to be penalized. The hateful abounds in her; but she knows no better. There is also loveliness and matter for rejoicing; products of evolution which are an altruistic joy; milk to feed the young, maternal care, the dog as our companion. But that does not prove her or evolution benevolent. For natural knowledge, if we hold natural science to be that knowledge, the natural world as phenomenon becomes a vast thing wholly uninfluenced by 'values'. The appeal to Design has lapsed as an argument and that leaves Nature acquitted not only of good but of evil. More literally than ever 'there is nothing good or bad but thinking makes it so'; and Nature has in that sense no 'thinking' outside man's. He and his ethics stand alone. There is nothing good nor bad except himself.

To look round at the world and find there nothing whose thought partakes his 'good' or his 'evil' excites in man a strange sense of loneliness. Laforgue turned from the stars and midnight sky saying, "comme nous sommes seuls pourtant sur notre terre!" He felt the pathos of that detached remoteness from even the nearest sky-comrade, unreachably afar. But that is not man's loneliness to the full. His crown of loneliness is his loneliness 'at home' within the compass and amid the community of his planet. The human mind is strangely placed there; no other mind its equal, let alone superior to it. All other mind its inferior, and almost incomparionably so. His thinking is thus thrown utterly upon itself. Grappling with its newly found 'values', yet with no experience except its own, no judgement but its own, no counsel but its own. Marked out it would seem, to be leader of life upon the planet, more, willy-nilly set so, he yet has none to seek guidance from. None of whom to ask a question. What wonder his religions seek to supply a Higher Being to meet his need in this? The sole counsel he can take, and he must seek it to the uttermost, is with the facts. He will need all his qualities. His kind must co-operate together to the last man.

Man's spirit thus yearns for company, comradeship, angels—even demons. His mediaeval thought had judged him a thing apart, but never allotted to him a loneliness such as this he now is conscious of. Nothing at all outside himself with which he can commune on what is next his heart. Was it not Kant who wrote,* "I declare I am much moved toward the presence of immaterial beings in this world, to put my soul with them." Perhaps a like sentiment bred the dreariness which Goethe found insufferable in the materialism of his time, "its Cimmerian grey". Facing this, in comparison with himself limitless, 'surround', which is fraught with good and evil but is, it would seem, unaware of either, man now knows enough of it to know that itself and he are none the less parts of one and the same. There was a time when he nursed the notion that he stood a thing apart, even somewhat after the manner of an Olympian or of one of the host of heaven. He was wont to think of man and Nature as two contrasted empires. He thought of himself as an exception to the order of the rest; not a wheel geared in with the other wheels. "Most of those who have written on the ways of men have done so as though those ways were no part of Nature. As though forsooth they were not controlled by the general laws of the universe. As though they were something outside Nature." Poles apart in much, there Spinoza and Aristotle were at one. Science today concurs. It tells man that he is a product of Nature. Broadly taken he is a product of his planet and its sun. He is a part of Nature. Even his mind

* *Sammtl. Werke*, iii, 58.

which would seem most to differentiate him is of the natural world and is part and parcel with the Nature round it. Its origins trace thence; its climax confirms its origins. Its habitat and it correlate. Each give the other meaning, even as lock and key.

He can however feel of himself and of the world which holds him that he, as evidence goes, is the sole part which glimpses them together as a whole. He finds the whole more than a mere whirlpool, motion without progress; it shapes as a motion with an onward progress; a pattern of movement which has long been moving toward what it is, and is not to stay at what it is. He feels that he has been a product of its moving onward. He feels that both he and it, now that his glimpse sees 'values', offer both 'good' and 'evil'. One* of my predecessors in these lectures invoked Keats's well-known phrase of the "valley of soul-making" † as "unquestionable truth" about this juxtaposition of world and man and good and evil. Man viewing himself as an item of the planet's side feels driven to think his meaning there is as a soul in "a valley of soul-making"; and Keats had added "I say soul as distinguished from intelligence".

How far as yet is this soul made? How far has it got? Millennia of infliction of pain in the old infra-human days and without one minute's mercy—until man's advent. Even then, how much of mercy? Civilized man devised and frequented the games at Ephesus. Do not we now walk unmoved across the city slums? It must be so or they would not be. This suffering which is part of Nature's plan, man does not escape it, and neither does he remit it. He himself still stands part guilty of it, not only by omission but commission. Need I cite an instance? Let a voice recently hushed remind us.

The Blinded Bird. ‡

So zestfully canst thou sing?
And all this indignity,
With God's consent, on thee!
Blinded ere yet a-wing
By the red-hot needle thou,
I stand and wonder how
So zestfully thou canst sing!

* Bernard Bosanquet, *Gifford Lectures*, Edinburgh, 1912.

† *Keats' Letters*, vol. ii, p. 362; letter 114.

‡ Thomas Hardy, from *Moments of Vision* (Macmillan), by permission.

Resenting not such wrong,
Thy grievous pain forgot,
Eternal dark thy lot,
Groping thy whole life long,
After that stab of fire;
Enjailed in pitiless wire;
Resenting not such wrong!

Who hath charity? This bird.
Who suffereth long and is kind,
Is not provoked, though blind
And alive ensepulchred?
Who hopeth, endureth all things?
Who thinketh no evil, but sings?
Who is divine? This bird.

Here survival of the sub-human becomes the more horrible because implemented by intelligence of human grade.

Man's altruism has to grow. It is not enough for him to stand and deplore. That is less to mend things than to run from them. A positive charity is wanted; negation is not enough. In effect it needs a self-growth which shall open out a finer self. It requires to absorb into 'feeling' something of the world beyond the self and put it alongside the interests of the very self. That asks biologically an unusual and even a perilous step. Such expansion might be a risk to the biologically exclusive sacredness of the self, the point d'appui of 'zest-to-live'. The self is the biological pivot of the individual. To exteriorize 'feeling' to the degree of fusing with the 'self' certain interests of what the physicist might call the 'field' could threaten the whole individual's balance as organism, displacing it from its pivot. Such fusion is tantamount to decentering the self and admitting certain 'otherness' to interest on a par with the self's own. But such altruism would provide awareness of others' suffering with psychical intensity more than that of mere observant intelligence. It amounts to sharing suffering as though another's suffering were the self's. To sense a star is not for our awareness to be the star, but when we sense pain it is that our awareness is that pain. A great gift—some might say divine—comes to the 'self' when perceiving certain suffering external to itself it so reacts to it that that suffering becomes its own, and is shared even as a 'feeling'. That gift is a gift, it would seem, uniquely human. It allots to human life a place unique among lives. It raises human life to a plane above the life which has not it. It is in mankind an attainment not reached with broadcast equality. There have been planes of our human being where men have gone "not thinking of much else than that they had enough of life to make them somewhat glad, when life went well with them." That attitude, in comparison with this other, argues an insouciance amid the misery of others which stands below what can be considered the proper human plane.

> 'None can usurp this height' returned the Shade,
> 'But those to whom the miseries of the world
> Are miseries, and will not let them rest.'

Altruism as passion; that would seem as yet Nature's noblest product; the greatest contribution made by man to Life.

At first glance such altruism may strike the biologist as contrary to the broad trend and polity of life. That makes the more notable the fact that evolution nevertheless has brought it about. Nothing shows better than it that Man is Nature's beginning to be self-conscious. But biology cries, "the individual for itself". The individual? What are the most successful individuals which Life has to show? The multi-cellular. And what has gone to their making? The multi-cellular organism is in itself a variant from the perennial antagonism of cell and cell. Instead of that eternal antagonism it is a making use of relatedness to bind cell to cell for co-operation. The multi-cellular organism stood for a change, in so far, from conflict between cell and cell to harmony between cell and cell. Its coming was, we know now, pregnant with an immense advance for the whole future of life upon the globe. It was potential of the present success of living forms upon the planet. Implicit in it was for one thing the emergence of recognizable mind. It was among the many-celled organisms that recognizable mind first appeared. It is surely more than mere analogy to liken to those small beginnings of multi-cellular life of millions of years ago the slender beginnings of altruism today. Evolution has constantly dealt with the relation between physical and mental as more than mere analogy. The bond of cohesion now arising instead of being as then one of material contact and interchange between related cell-lives is in its nature mental. It is a projection of the self by sympathy with other life into organismal situations besides its immediate own. It is altruism as passion. It marks, we may think, at the present time the climax of mind. It is well to note it is not essentially rational. It is often more germane to emotion than to reason. It belongs, if you will, to sentiment, and it can elevate sentiment so that reason at best ranks but as a tool for sentiment. It creates a reasoned emotion. It may have the conquest of the world before it, in which case reason will play its part, as a tool. It may likely mean a human future led by women more eminently than by men. There rises to the lips, perhaps a little wantonly, the simile of a bird's brain with human cortex appended, a bird's mind with human intelligence attached. And we remember the true bird-mind is of newer type than is our own.

Taking Nature broadly, altruism as yet has little place there. Are the shoal and the herd altruism? Nevertheless, if our new-found civilizations teach us anything, human altruism is growing. Perhaps the highest mass-product of man's civilized society has been the 'human' peace within its border. Peace, though not altruism pure, is yet greater opportunity for greater altruism. Altruistic sympathy as permeating peoples may be small as yet; but, as the periods of the planet reckon, civilization itself is young. Who shall foretell the possibilities of the future? If in the past the cohesion of families of cells in due course transformed the whole outlook of life upon the planet, shall not the psychical cohesion of individual lives carry that transformation further, with such consequences to the flowering of life as beggar our fancy to conceive?

Man asks, is it inevitable, all this inflicted suffering?

> Ah Love! could thou and I with Fate conspire
> To grasp this sorry Scheme of Things entire,
> Would not we shatter it to bits—and then
> Re-mould it nearer to the Heart's Desire!

There springs in him a spirit of insurrection. Standing on his planet he, its own product, harbours rebellion against the process which has enthroned him. Mind awakened by distress of mind. His altruism is in bud.

We approach here one of the great conflicts which devolve on man. Our milieu, so far as we explore it, appears a battlefield almost from end to end. Our world is in process of becoming, and that becoming is not of peaceful course. It meets on all sides obstacles and perplexities. It engages battle with them. One of those battles is between Man and Nature. Man is in conflict with Nature. We have not here to touch upon man's two other and still greater conflicts; man against man, and man against himself. Our theme is Nature and man as part of Nature. As part of Nature man is deeply involved in conflict with the rest. I would think it a theme even as those others not unworthy the epic and the lyric.

Man, surveying evolution and the situations it creates, finds that his understanding quarrels profoundly with them. Will such revulsion of the product against the process ensue each time that evolution reaches something which can evaluate the process which brought it forth? Then the process would seem, in part, frustration of itself. Yet that is where man stands. His mind makes him a critic of the régime in which he is, and much of it as critic he condemns. That seems a strange sequel to the secular process which has cast him up on its shore. Or does some obsession push him into error? He is placed in the position of being an adverse critic of his one dearest possession, life. He is becoming an adverse critic of his own 'zest-to-live'. But life without 'zest-to-live' will assuredly perish. His criticism replies that even as 'self' is the driving force of life so there is need for the human self to sublimate its narrow obsession for its own existence into delighted service of a 'self-in-common'.

Altruism is confronted by the old primordial 'urge-to-live'. There rises a great antinomy which man's life has to face. Between man and the rest of life truly a new difference has arisen. He on his planet stands as the one life critical of life. His altruism confronting the old 'drive-to-live', is an antinomy which divides him from all other lives he knows. It comes to this, that in his instance 'zest-to-live', before it endorses life, now makes 'conditions'.

The thought comes to him of a new order which should supervene upon our planet. At present it is a place of cross-purposes. Man's fancy has shaped the Happy Isles, and the Utopias of what might be. Religions have promised Paradises, but *after* death. Science, looking forward, has pictured a Solomon's House in a New Atlantis. It was Joseph Priestley, writing* amid the discontents of his time, twenty years before the French Revolution, foresaw issuing from Science a future "glorious and paradisiacal beyond our imagination". "Nature, including both its materials and its laws, will be more at our command; men will make their situation in the world abundantly more easy and comfortable; they will probably prolong their existence in it, and will daily grow more happy." The prediction was correct, save for its concluding sequitur, which as we hear it now rings as a non-sequitur. Priestley's enthusiasm had thought greater knowledge must mean supremacy of 'the values'. It might but it did not. In all this man can look for no help from any mind on his planet but his own. He has to realize that if he was born to direct, he must shoulder his responsibilities and direct, using his own judgement. He is the only recognizer of 'values'. He is 'the master of his fate'! Rather, it would sometimes seem to him, he is merely a tragic detail in a manifold which goes its way without being even conscious of him. A lonely motive in a more than million-motived construction whose whole motive, if it have one, is unknown to him except as alien to his own and his to it. Master of his fate? Around him torrential oceans of energy; and his own energy by comparison a drop which trickles down the window-pane.

But he has mind, and his mind knowledge. Science as knowledge of energy might help him. Remembering that science has not the words 'suffering' or 'good' or 'bad', he must, to secure his programme, yoke science to his own anthropisms. Supposing that, in the domain of his own planet, he could prove master of his fate, what then were his programme?

We heard Joseph Priestley's forecast from 170 years ago. What are the forecasts of today, taken similarly with applied science in view? "The vast wastage of natural power by blind competition between multitudes of species which are indifferent to human requirements need not continue if man now applies his scientific knowledge to a deliberately planned project for eliminating species which compete with him for the means of

* *Essay upon the Principles of Government*, 1768.

satisfaction, conserving only those which, directly or indirectly, contribute the means of food, of shelter, ornament and a pleasing prospect." * As to the means. "The first is how to control the physical agencies which limit the survival and quality of species which subserve human needs. The second is how to destroy competing species which do not subserve human needs. The third is how to preserve edible species. The fourth is how to improve the quality of propitious species by selection of suitable varieties." † "Selective elimination of species can be accomplished by various methods of which the most important are regulation of the physical environment, segregation, specific poisons and hyperparasitization." ‡

We notice here how Nature as man's background has with man's greater knowledge moved further from Sabunde § and nearer to Hume, and how the tone of man has become more than before that of an earth-dominating conqueror. The planet is his; a motif of his programme is so to regard it. It is his not by any mediaeval reason of Heaven's gift but by right of growth of mind. We note too that his interests are reckoned the only ones which count. That other life is valued or reprehended not for itself but as it affects man's. I would not be thought to question, still less to oppose, Prof. Hogben's view which I think, if I may say so, enlightened and representative. What I desire is to take it as it is and follow as it seems to me some implications of it. Man's self is the whole theme of this his ethic. Man's life is held to be a life apart and above the rest, not less than in Mediaeval Christendom or with Fernel, although on grounds quite other now than then. It would seem the 'zest-to-live' belonging to other lives than his own makes no appeal as such to man. The planet is *man's* planet. It is to be rescued from life which obstructs its being man's planet. Man's programme is the planet for one life, his own, and for such lives as are useful satellites to his. That at the moment seems the verdict of his 'values' on this part of the human situation. Will that, as his 'values' mature, be their steady view? Are we not, even if masters of our planet, yet its guests; and has it not other guests as well?

* L. Hogben, *Science for the Citizen*, p. 965, 1938.
† *Ibid.* ‡ *Ibid.* p. 967. § *Vide supra*, chap. xii, p. 364.

At least we are shown man recognizing his responsibility as a part of Nature. He is eyeing himself as a product of his planet and as a part of it. That he is lonely on his planet implies perhaps that, of all its products, he is *the* product. To be a part of Nature was at one time a thought abhorrent to him. It seemed a rivet in the bondage of his soul. But now to be a part of Nature he sees to be a means to his salvation. He sees himself a part whose rôle may be to re-order Nature nearer to ideals he has, at least to re-order his 'home' corner of the world. He sees Nature on his planet reforming itself through him as part of itself.

Man in his present mood goes to the full with that old protest we read in Spinoza. He finds his very ambitions are his as one with Nature. Nature is everywhere integrating and disintegrating unitary complexes, ions, atoms, molecules, plants, animals. He sees himself a unitary complex subservient to that trend. But he, it would seem, is a unit more complex than on his planet any yet before him. In him the two ingredients mind and energy are met to a unit with more liberal measure of mind than there is evidence of having earlier so combined. In the world of units the majority of units, an immeasurably vast majority, are doing their doings blindly, so far as he can read. Their doing is as unwitting as unceasing. With himself and his immediate kind not so. They alone, it would seem, among all the myriads of units have a picture, imperfect but still a coherent picture, of a whole manifold of doing. That picture, as he has pondered it, has grown clearer to him. It is a scene where certain conflicts proceed, which are by every standard condemnable. One life the curse of another life. It seems irrational mischief. Some lives graced by knowledge and committed to goodness and to ways of help to others; some on the other hand instruments of suffering and frustration to the rest. And man, while in some ways among the former, also in some ways is with the latter. If he would render help to his world he has at least one means. That is by his own contribution to human fellowship. The circumambient untraversable which isolates his planet does of its very self serve to compel man's fellowship with man. Man's specific loneliness in the economy of earth, he alone having the 'values', again compels it. Only amid human fellowship can 'values' be listened to and shared. In him evolution has shaped a social animal par excellence. A man wholly solitary would, said Aristotle, be either a god or a brute. Social life is his opportunity as field for his 'values'. To know that he is a life being evolved which carries with it the 'values' can imbue his social system with a purpose. Human fellowship thus emerges as something of unique worth. Fellow human mind is the sole mind to understand and share to the full with his, and be shared. The loveliest friend of man is man. That theme however demands a worthier pen than mine.

One part of Nature man can reach directly. He knows it well from struggles with himself. It is himself. Travelling the road he had come and rising from the unethical whence he rose, he can view himself compact of what his latter day has recognized as 'good' and 'evil'. Nature, a mindless process as it seems, commingles consequences evil and good; he was one of its products so commingled. Some of the hateful he saw about him was of his own commission, especially perhaps towards his fellow-men. Some also of the good seemed to have arisen with him. He must rely upon his 'values'. Dare he trust them, by them to judge the world? If he can, he has a criterion for the world. Sunrise and sunset *are* beautiful if one child feel them so. Shall he not think malaria an evil thing, to be deleted? Shall he not appraise the nightingale and evening star by 'values'?

As for action, however limited he is as 'power', the evil and good within himself at least are his to deal with. Did he aspire to control what his new-fledged ethic found evil in the great scheme which swept him onward, then to control it in himself were to control at least in part that evil. Nature evolved the 'successful' and he rated as one of her successes. Half a million years back he had been flaking flints in the open weather, shaping a weapon, perhaps to destroy an enemy at the cave-mouth, or to be in his turn destroyed; already then it would seem he had felt the beauty of a shapely hand-axe and also had laboured his hand-axe or his scraper not for his own use solely, but for his fellowship, a little group where death kept membership short-lived, and life went direly bare. And now a half million years later he counted his community by tens of millions and its cities belted the planet. He could reach by air in a day one hemisphere from the heart of the other. He could in a second of time send his spoken thought round the planet. The very gap of silence severing planet from planet he now dreamed of breaking. He was beginning to think in units of larger span, more minutely subdivided and more precisely measured. By reason of changes in him the planet now harboured mentality giving more scope to beauty, and more play to altruism.

In him, it would seem, evolution had prospered. Other successes it had had. Time had added his to those others. Successive forms of life had arisen, dominating the planet through certain epochs. They had had each their turn. The record of the planet's rocks told of the ammonites of the warm ancient oceans. They had flourished and swarmed. They had gone their way. They were but fossils now. The great Saurians in their turn had prevailed, battening in the rich river plains, towering prodigies of strength and stature not since repeated. They too had had their day. Their reign had been long, and then they had vanished. Today it is man's turn. A single form and yet the dominant life, so obviously that a glance suffices to show it. What did it mean? Is man one more experiment which Nature makes, later to scrap it? It may be so. Time has brought man his turn to come and then to go? Or did it mean more? Could it be that man would stay? Nothing did stay. The others each had had a spell, in turn to be replaced. There seemed already streaks of sunset across the human landscape. But there is in his instance a new factor, or one at least strangely prominent in it: mind. His oncoming had been an outstripping of other minds. His dominance pillars on mind. Will that ensure its future?

There were it seemed in his own stock as elsewhere in the ranks of Nature two bents of mind, a social and a predatory. Man's mind was patched with both. His was, he knew, like other lives, a resultant of 'gene-complex' and its 'surround', a blend of genotype and nurture. During his long early participations in wild nature, the predatory streak in him had for the time being served his and its turn. There had been ice for it to cut and it had cut it. Issuing from that earlier nature, his kind had then, through recent millennia, elaborated communities. The communities had elaborated within themselves organizations of sanctions and tabus, in short, civilizations. Civilizations, growing, had proved prolific of new mental acquired characters. Indeed civilization itself was largely a system of such characters. It was a system in which naked predacity became more or less tabu. Not that civilizations were all alike; each had its social idiosyncrasy. There were types of civilization, just as there were strains of mankind. Of the two factors, gene and nurture, civilized man was in every instance a resultant. Predacity was much less evident in some resultants than in others. But its type persisted, and where stressed it gave what can be called *homo praedatorius* 'predaceous man'.

For the undertaking by man of the rôle of master-life on the planet, 'predaceous' man may well be a competitor against truly social man. It would be a step fatal to the undertaking if predaceous man were to obtain ascendancy. There would then be little promise of man's staying power at all. There would be little chance of any enduring organization by man upon the planet. Predaceous man would cut away the ground from under his own feet, inasmuch as the solidarity of mankind is necessary to the undertaking, and that solidarity is impossible with predaceous man. Predaceous man unlike other forms of predatory life preys on its own species. With predaceous man civilization itself becomes of predatory type. Predatory war enters then as a feature into community-organization. Since predaceous man is human, in his instance the human mind itself implements predacity. Field after field of human civilized activity becomes a scene of conflict little less internecine than is war. Economic warfare, commercial warfare, class-warfare, are symptomatic of *homo praedatorius*. Serfdom and slavery attach to his régime, in fact when not in name. His régime deals by opprobrium and ostracism with victimized classes in the State. He exploits cruelty on sub-human lives as well as on human life. Predaceous man's rule cuts indeed at the very root of social mankind's organization of life.

It can be argued for predatory man that there is so to speak an immense tradition of Nature behind him. That his ways are ways which have obtained in Nature from the earliest times—perhaps since living Nature first was living Nature. That he therefore is so to say the orthodox in Nature. We saw indeed how in some large domains of living Nature the order there established is—we have to recognize it—'might is right'. In great measure that too is the order of life of predaceous man. His is today's continuance of that old order, by him enlarged and, he may think, glorified and, if we can allow the term, refined by the powers of human thought which he, being man, has. It is true then that his régime has the authority of millions of years of life behind it. It conforms with 'natural' conditions which are perhaps as old as life itself.

But there is to be remembered as regards the polity of Nature that we find—and the planet's whole story demonstrates it—a still older law, namely, change, progressive change, a law older even than life itself. This tells us that the abiding of a *status quo* is not, and never has been, 'lawful' in Nature. A *status quo* would be a breach of law, if Nature's law were breachable.

> The old order changeth, yielding place to new,
> And God fulfils Himself in many ways,
> Lest one good custom should corrupt the world.

That the predatory as a way of life is still observed by newer forms of life is in its measure an indictment against them. It is in principle a *status quo* persisted in after becoming due to disappear. 'Might is right' as a principle in the newest phase of life would seem doomed because it exemplifies in principle a *status quo*. Therefore, that predaceous man has an immensely long tradition behind him is no sanction for him; it may be an excuse, but it is no authorization; it would authorize anachronism. It would seem that *homo praedatorius* is in a backwater unreached by the tide which set in some millennia since. The great revealed religions bringing their altruism are evidence of that new tide. It may be that the reason why the tide of altruism set in, was as a step toward a re-ordering of life upon the planet. The ascendancy of *homo praedatorius* would spell ruin to man's prosperous leadership here. And man must lead or go. To lead is all he is fit for. But leadership does not lie in treating as prey those whom it leads. Man is above all a leader charged with survival of the 'values' which are in his keeping. Man's leadership cannot be tyranny since that would be to forget the 'values'. With the 'values' his leadership must be some form of fellowship. The cement of fellowship is altruism, for that is truth to fellowship. Fellowship cultivates equality of 'selfs', equal respect for values and equal rights in values. It asks man to be watchful against himself that he harm not his neighbour. Altruism as basis of co-operative effort, to guide some of the ways of life to nobler common issues. There is so much for men to do in common. The means? Knowledge? No, knowledge is not enough. A new form of 'zest-for-life', with knowledge for its tool.

Man knows that he is changing, willy-nilly changing. Could he but guide his changing! Conforming to a type he is yet always as individual unique. Not wholly like any other which ever was, from the dawn of life through all the ages up to this present, and it would seem for ever, as long as life may be. The inorganic world is possibly a mere assembly of types, but the organic world is one stream of individuals. No following life is like the one it followed. That states perhaps the utterest poignancy of death.

Thus the new individual is life's opportunity for change. The individual in biology today looms larger than ever before. Did Ray, Linnaeus, Cuvier, when they set out to enumerate the variety of life realise to the full what they were doing? Their counting of species was not the exhaustion of variety. It was reaching the beginning of a new order of variety. They were approaching the clue to variety. Medicine had never been allowed to forget the individual in the type. Medicine's problem has always had to face the actual individual. Hence ancient Medicine's wisdom about 'temperament'. Aristotle, as against Plato, knew that what matters is the concrete individual, that the individual is the approach to reality. Today the individual shows forth to us as a mosaic of genes. Owing to its linkage making and linkage breaking the permutation of gene-complexes sows our world with individual variety, which Nature's nurturing lap develops further.

Of course individuality like all else lends itself to exaltation as a fetish. To chasten that trend we have but to remember that one segregation of individuality is the mad-house. Let that be. The high significance of the individual is 'change'. Change it may be to better, it may be to worse. Always the individual stands as a signpost pointing somewhither. Not all directions are, we may be sure, equally good. Our old friend, as we may by now call him, Jean Fernel, even as far back as his mid-sixteenth century wrote* "The beginnings of our being are therefore of much matter to us; those who are of health by birth are not a little fortunate. By consequence it would be a great good for our race if solely those who are sane and sound gave themselves to the making of children. For if the husbandman know that for the sowing of the land the best seed is to be chosen, having found by experience that from a poor seed we can expect only a miserable harvest, how much more strictly should that be practised in the propagation of our species."

Today watching and indeed asking for change within ourselves we note that here our being holds out opportunity which might be turned toward bettering it. "Man's understanding and control of the living body today are not less than of inanimate nature a century ago,"† writes Professor Ralph Gerard. To guide individual variety could better the world, if man knew what is better. Under evolution the motto of the planet has been 'more life'; under man's leadership it should be 'better life'.

If we accept the story behind us, the planet, which being blind never before had purpose, now is lent a purpose and—anthropism of anthropisms!—by man. Looking at the face of the vast Universe, it may seem in this we reach a bathos risible even to ourselves. It pleads excuse because a broken light. Hume's Philo spoke in bitterness of Nature. He reproached it, we remember, with being 'a vivifying principle bringing forth its countless offspring into suffering'. He spoke in bitterness of its blindness. But he himself was an outcome of that Nature; and he was at least a part of Nature beginning to understand itself.

Might not Nature, so bitterly apostrophized by him, make answer. "You and yours once thought me rational; you said I had foresight and a purpose; you declared I had plan while I created; you read into me a super-intelligence and design. Now that you have undeceived yourself about me, you seem to take it ill that where you used to say I showed intelligence, I show none; where you used to find design you find now none. But

* *Medicina*, Paris, 1554, *Pathol.* bk. I, cap XI. Burton's *Anatomy of Melancholy* in the next century commended this passage.

† *Science*, vol. LVIII, p. 367.

what would you? That I aped intelligence was the making of you. Aping intelligence as I did, it required intelligence to read my pseudo-logical doings. If I had been chaos what good would it have been for you to have intelligence? Intelligence amid chaos would have had no survival value. You would therefore not have had intelligence. Intelligence is yours because it helped you to understand what you misunderstood me to be. That justified your having it and so you have it. It was my pseudo-intelligence sharpened your wits. You thought me rational with 'forces' and 'causes' and 'purposes' and all the rest and so you got your endowment of reason, reason being a means for dealing with what seemed reason. And now your thus begotten intelligence seems to revile its only true begetter, for seeming to it to be what it was not! At least you should thank me for being 'law'. That it was which made you and has given you mind."

And Nature might continue: "For you it will be to remember, having got your measure of reason, you are now in fact in competition against a measure of reason as well as of mere semblance of reason. You will have to deal with it as a new situation. For you have your own fellow-folk to deal with; and I made it endowment for you all. Bethink you too that others, besides merely you and they, may also obtain it. Remember too that it is not going to stop where it is—the modicum of reason which you and they have—because an extra dose of it can have survival value. You have now as a species had a long innings by reason of your intelligence. It is nearly a million years since first you were knocking stones into shape.

"You thought me moral, you now know me without moral. How can I be moral being, you say, blind necessity, being mechanism. Yet at length I brought you forth, who are moral. Yes, you are the only moral thing in all your world, and therefore the only immoral.

"You thought me intelligent, even wise. You now know me devoid of reason, most of me even of sense. How can I have reason or purpose being pure mechanism? Yet at length I made you, you with your reason. If you think a little you with your reason can know that; you, the only reasoning thing in all your world, and therefore the only mad one.

"You are my child. Do not expect me to love you. How can I love—I who am blind necessity? I cannot love, neither can I hate. But now that I have brought forth you and your kind, remember you are a new world unto yourselves, a world which contains in virtue of you, love and hate, and reason and madness, the moral and immoral, and good and evil. It is for you to love where love can be felt. That is, to love one another."

"Bethink you too that perhaps in knowing me you do but know the instrument of a Purpose, the tool of a Hand too large for your sight as now to compass. Try then to teach your sight to grow."

Is this then too sombre a reading of the natural world? This is at best but 'an interim report'. The world runs for all to read. We go about and many of us are glad; and all of us are glad at times. To have natural knowledge we commonly account a joyous thing; but it is clearly a saddening thing as well. Nature is like a music to which two friends can listen and both be moved and yet each by a different train of thought.

And the pursuit whose quest is Nature's understanding, has this among its rewards, that as it progresses its truth is testable. Truth is a 'value'. The quest itself therefore is in a measure its own satisfaction. And as we approach Nature's verity we receive the lesson that our advance to knowledge is of asymptotic type, even as continually approaching so continually without arrival. The satisfaction shall therefore be eternal.

Hume's Dialogue puts the question whether the pain of the world is or is not offset by its joy. The answer to that by Thomas Hardy was "surely God will soon close down the human show with its misery". But that was too hasty a prayer. One thing we can discern about Nature as a factor in this question, an element in this situation; at least it is a harmony. Now that the magical has been exorcised from it we can feel the vast unbroken harmony it is. Where tragedy and where comedy and where both it is at least a harmony all its own. That we should have attained that knowledge, that it should be given to us to apprehend that, that we can follow its being that, can hear it, trace it, retrace it in part and even forecast it as such, is an inexpressibly estimable good. We are privileged in this. It is, so far as we detect, uniquely the possession of ourselves—it is *the* human possession. When Cleanthes speaks of compensation for pain—there is here compensation. It is the old primeval gift of knowledge, which we, wiser now, know was not primeval but is of yesterday—therefore with promise of further. We traced how, it would seem, we are so fashioned that our world, which is our experience and is one world, is a diune world, a world of outlook and of inlook, of the experienced perceptible and of the experienced imperceptible. This world with all its sweep of content and extent taxes utterance to indicate. Yet it is given us in so far to seize it, and as one coherent harmony. More; it is revealing to us the 'values', as Truth, Charity, Beauty. Surely these are compensation to us for much. And will not this compensation grow? Charity will grow; Truth grows; and even as Truth so Beauty. Music as her ear grows finer embraces what once were discords. The mind which began by being one thing has truly—as so often in evolution—gone on to being another thing. Even should mind in the cataclysm of Nature be doomed to disappear and man's mind with it, man will have had his compensation: to have glimpsed a coherent world and himself as item in it. To have heard for a moment a harmony wherein he is a note. And to listen to a harmony is to commune with its Composer?

One word further. Natural Religion? The foregoing may submit a situation, but does it offer a religion? Let us turn to the great religions. They move communities. They have moved and transfigured vast communities. They live enthroned as the faiths of peoples. They organize pious sects and found orders. Natural Religion has not done these things and is not doing them. It would seem without even the desire. Its ideology seems wanting in appeal as beside those, the other religions. Religion has emotion and communicates it. What of a religion which does not move us? Is it a religion? The spirit whether of brute or man is impotent of accomplishment unless it have emotion. Without emotion could a bird build its nest?

But Natural Religion has convictions; it must therefore have emotion. Its convictions entertain 'values', and the 'values' constrain emotion. We saw that one of its 'values' is Beauty. Also it knows the sentiment of wonder. Now that Nature is freed from the pseudo-marvels of magic, wonder is for it a truer wonder. Wonder at natural law, to our experience universal and infrangible. Law which has generated in us capacity for inference and reason; whence it is we have them. And there is Truth. Natural Religion along with the great religions holds truth a 'value'. As to it Natural Religion exacts a credibility somewhat other than do they, or, rather, demands another standard of credence. They and it pursue truth, but, for Natural Religion what it holds to be true must be verifiable with an austerity all its own. It regulates, by recourse to observation, reason's acceptance of what claims to be true. It tests against accessible fact the inferences of its reason. For it 'report' * is not enough. This asceticism in regard to belief is sometimes spoken of as 'use of reason' as distinct from 'use of faith', but that phrasing is too crude. Reason and faith both play their part either way. Rather the criterion is the requiring, for acceptance of 'report' as valid testimony, confirmation by the experience actual or potential of the 'self' receiving the report.

This purist attitude toward credence, restricting acceptance of evidence from 'report', does in fact evade much contributory emotion. 'Report' which ordinarily is personal report habitually abounds in emotion; the personal tends to be laden with emotion. Indeed to refuse testimony by way of 'report' is partly to withdraw from the 'group-mind', and that means withdrawal from a large field of emotional activity.

Acting in that same direction, towards parsimony of emotion, there is a further feature of Natural Religion. Natural Religion consults Natural Science. Natural Science divests itself, as we saw, of the anthropomorphic. It has shaken off astrology and magic, which were anthropomorphic, and it has set about freeing itself from other anthropisms. In past times the questions it put to Nature it put in the form of 'why'; the answers then could not but be anthropomorphic. Today its questions to Nature are couched in the form of 'how', and the answers are consequently further away from human metaphor. The eschewing of anthropomorphism by Natural Science affects Natural Religion, in consultation as the two are, and Natural Religion in its turn restrains anthropomorphism.

* *Vide supra*, chap. XI, p. 336.

Anthropomorphism is perforce charged with the human and the personal, and the great historical religions are frankly anthropomorphic. Anthropomorphism with its lien on the personal is always quick with emotion. Man is, after all, the great 'object of affect' for man; commonly the human is the strongest source of emotive appeal to human kind. Human doings, human feelings, human hopes and fears move man as does nothing which is not human. The great religions as part of their anthropomorphism cultivate the Deity as a personal Deity. That for their followers forms an element fraught with emotional drive of power, for some minds, elsewise unattainable. For one thing it draws on that exaltation of sentiment which attaches to personal leadership and on devotion to a personal Leader. If religion has to stir the world, let alone stir man to conflict with the world, the appeal to a Deity which is personal can go far to harness for its purposes the whole dynamism of the psyche. It is equivalent to establishing a 'value' which for its followers resumes all other 'values'. But this source of emotional strength Natural Religion is without, for it sublimes personal Deity to Deity wholly impersonal. In a manner the Θεός of Aristotle is that which it re-approaches.

But that is not to say that Natural Religion has no emotion. Without emotion it could not dream of the tasks it does dream of; for instance that one of them—for its pre-occupation is always with what Jean Fernel called the sublunary—the altering of the existing order on its planet's side. Granted it can dispense with founding temples and establishing rites, yet it will be incommensurate to its own self-proposed enterprises unless it have passion. Whence then the passion it has? Surely Truth, Beauty, Charity provide passion. The very austerity hedging its acceptance of Truth illustrates the price it puts upon that 'value' and will pay for it. At great cost it would have the truth about Nature–Nature which for it includes man. Its curiosity to know that truth is no mere worship of Reason. Reason it takes for its slave. Reason it says is not a 'value'; it is just a tool for thinking. The aim, the zest, which can employ reason is that which constitutes the 'value'. And that purpose here, is passion to know the 'secrets of Nature', as the old phrase has it. It would seem a propensity broadcast in humanity, yet, in some minds stronger than in others. "If I could spend the course of everlasting time in a paradise of varied loveliness I do not fancy my felicity would be greatly impaired if the last secret of the universe were withheld from me." * That does but tell us that the understanding of Nature is no premise in the argument of Nature's beauty and that this emotion for understanding is distinct from that of Beauty. Attaching to it is the condition that to satisfy it what is arrived at, what is learnt, must for it be 'true'. That is a feature of this passion. It is a 'sacred' curiosity, though, as would seem, not equally sacred to all minds. "I could not rest in a truth were I compelled to regard it as hateful." That of itself assures us this pursuit of truth involves emotion.

Natural Religion has not forgone emotion. It has simply taken for itself new ground of emotion, under impulsion from and in sacrifice to that one of its 'values', Truth. Its view of the world and of itself is based upon the purview of what by its lights it can accept as true. In that way, for it, much that is comfortable in other religions lapses. If you will, man's situation is left bleaker. One feature of that situation is that the human mind, such as it is, is left the crown of mind to which human life in all its needs has direct access. Compared with a situation where the human mind beset with its perplexities had higher mind and higher personality than itself to lean on and to seek counsel from, this other situation where it has no appeal and no resort for help to beyond itself, has, we may think, an element of enhanced tragedy and pathos. To set against that, it is a situation which transforms the human spirit's task, almost beyond recognition, to one of loftier responsibility. It elevates that spirit to the position of protagonist of a virility and dignity which otherwise the human figure could not possess. It raises the lowliest human being conjointly with the highest, Prometheus-like, to a rank of obligation and pathos which neither Moses in his law-giving nor Job in all his suffering could present. We have, because human, an inalienable prerogative of responsibility which we cannot devolve, no, not as once was thought, even upon the stars. We can share it only with each other.

* W. MacNeile Dixon, *The Human Situation*, p. 14, 1937.

THE END

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